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SURGERY OF THE PANCREAS,

AS BASED UPON

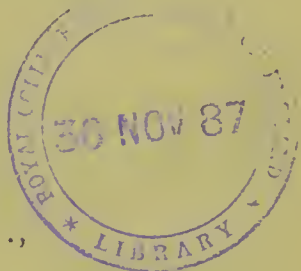
EXPERIMENTS AND CLINICAL RESEARCHES.

BY

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IN the following article, an attempt will be made to lay the foundations for a rational method of treatment of some of the injuries and diseases of the pancreas by direct surgical measures. The literature on the surgery of the pancreas is exceedingly scanty and loosely scattered through the medical journals and text-books, as no previous attempt has been made to arrange the material in a systematic form for ready reference. Our present knowledge of the surgical treatment of diseases of the pancreas is limited to a few operations performed for the cure of retention cysts, by excision or the formation of an external pancreatic fistula. The clinical material which I have collected, and more particularly the description of pathological conditions found within and around the pancreas at post-mortem examinations, will be utilized for the purpose of pointing out new indications for operative interference, by such methods as will suggest themselves from the results obtained by experiments upon animals.

I. COMPARATIVE ANATOMY OF THE PANCREAS.

A few words on the comparative anatomy of the pancreas are necessary in order to compare the results obtained by certain experiments with similar conditions when observed in the human

subject as the result of traumatism or pathological changes. In some of the higher invertebrates certain organs connected with the alimentary canal have received the name of pancreas; but they have done so rather from their position and inferred function than from any certain evidence of their use, or from their anatomical structure.<sup>1</sup> If they exist, they consist of simple cæcal appendages attached to the upper part of the intestine.

In the osseous fishes, certain cæca or blind tubes may be seen at the commencement of the intestinal canal, close to the pylorus, which from their position have received the name of pyloric appendages, and have been regarded by most anatomists as the analogue of the pancreas in higher animals. In reptiles, we make a greater approach to the structure of the pancreas of higher animals, both in form and structure. In the frog the pancreas is shaped not unlike that of the human subject, but its broad end is in the opposite direction. It is in close approximation with the duodenum in its whole length. A proper duct cannot be found; probably small ducts from different parts of the gland open into the biliary duct as it passes through the gland. The pancreas of birds is proportionately larger than in any other animal. The gland has always more than one, usually two or three ducts which open by separate orifices and often at some considerable distance from one another.

The chief differences between the pancreas in other mammalia and man relate merely to its color, its consistence, its degree of lobulation, its form, its volume, its union into a single mass or its separation into two distinct parts, and, lastly, its position and relations with different portions of the peritoneum.

Its form is generally more or less that of a narrow band, divisible into two portions: one, the duodenal, following the curvature of the duodenum, and placed vertically or obliquely; the other, the gastrosplenic, extending transversely, and therefore opposite the other, from the duodenum to the spleen, against which it rests; the latter is always developed, the former is often defective or absent, and must be considered merely as an accessory portion.

<sup>1</sup> *Cyclopedia of Anatomy and Surgery*, vol. v. p. 90.

In the carnivora the pancreas is always large in proportion to the size of the animal. In the ox, from the distinctness of the two portions, the organ has a bilobar appearance. In the horse, from the gastrosplenic portion being doubled, it has a trilobar form. In the rodents, the organ is spread out in an arborescent manner, in an extensive mesentery that imparts free movement to the long duodenum, and extends to the left in a sort of omentum which underlies the stomach. In the rabbit, the duct enters the intestine nine inches or a foot from the pylorus. In the mammalia, as in man, there is usually but one pancreatic duct, which enters the intestine near the pylorus, although sometimes a great way removed from it. There are, however, considerable varieties of insertion. In the lion, two pancreatic ducts join the common bile-duct separately, one near the other. In the dog, I have made the observation that the ducts from both portions of the pancreas unite near the duodenum or within its wall, and that the orifice of the common pancreatic duct is usually located about an inch or two below the opening of the bile-duct. If an accessory duct exists, it usually opens into the intestine at a point in common with the bile-duct.

Berard and Colin (Canstatt's *Jahresbericht*, 1857, 1-3, p. 64) have shown that the pancreas is not connected with the duodenum in young dogs. It consists originally of two parts, of which one lies parallel to the duodenum (caudex inferior), and the other perpendicular (caudex superior). These two portions join later to form a mass which becomes adherent to the duodenum. Each portion has its own duct, which afterward join to enter the intestine about two and a half centimetres below the opening of the bile-duct. Sometimes there is a second duct arising from either portion, or more rarely from both, which enters the duodenum by the side of the bile-duct.

The pancreas of the pig has usually only one duct, but when two exist, the second smaller duct communicates with the principal duct which opens into the common bile-duct.

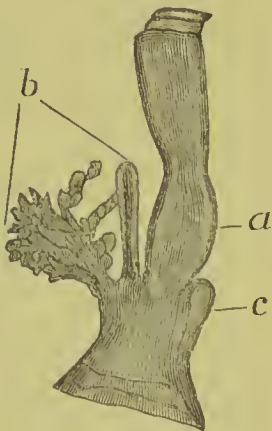
The irregular distribution and insertion of the pancreatic duct in mammalia and the frequency with which a second and third duct is found, are important to remember in connection with ex-

periments on the pancreas, by intercepting the secretion by ligation of the duct, as it is exceedingly difficult if not impossible to ascertain the existence or absence of the small accessory ducts, and on this account it would be impossible to prove that all of the outlets of the gland had been intercepted, even if more than one duct had been found and ligated.

## II. DEVELOPMENT OF THE PANCREAS.

Remak has studied the development of the pancreas in the young chick ("Entwicklung der Wirbelthiere," Berlin, 1855, pp. 54, 115, 164). He found that the matrix could be seen somewhat later than that of the liver—about sixty-five hours after incubation had commenced. It consists primarily of a bulging

FIG. 1.



EMBRYO OF CHICK, FOUR DAYS OLD.

- a. Stomach.
- b. Liver and bile-ducts.
- c. Pancreas.

of the hypoblast of the posterior wall of the intestinal tube, covered by a thickened prolongation of the connective tissue layer of the bowel. (Fig. 1.)

The embryonal pancreas shows in the beginning a cavity which is in communication with the open lumen of the bowel. The changes which take place in the embryonal pancreas during



the first five days can be readily observed and are easily understood.

From the thick wall of the hypoblast, numerous small, solid lobules spring, while the hollow space in communication with the bowel assumes more and more the shape of a canal. The connective tissue layer does not increase in size in the same degree, and presents no lobular projections upon its surface. On this account the new organ has assumed a pyriform shape externally; on the other hand, the glandular portion in the connective tissue layer takes on a branched structure. (Fig. 2.)

The hypoblastic layer is the basis of the parenchyma. Composed of cells, the connective tissue layer serves as the basis for the vascular constituents of the gland. The embryonal connective tissue disappears during the development of the gland in proportion as the cellular portion increases, until, finally, only enough connective tissue is left to serve as a nidus for the vessels and as a *membrana propria* of the acini.

The pancreas is not developed by symmetrical folding of both walls of the intestinal canal, but each wall grows by proliferation in different degrees to form the pancreas. The excavation in the rudimentary gland does not exist at first, but the original and essential structures are the cellular parenchyma of the gland from the epithelial lining of the intestine, and the vessel- and nerve-enveloping layer of connective tissue. As the pancreas in birds has two ducts, the question arose how the second duct is formed. The most plausible explanation was afforded by the assumption that the primary duct divides itself into two in a longitudinal direction. Remak, in 1846, found another explanation by examining two geese, between three and four weeks old. He found two ducts at a short distance from each other in connection with the wall of the intestine. A closer examination showed, however, that only one of the ducts, the upper, was in communication with the lumen of the intestine; the other presented a blind pouch adherent to the wall of the intestine.

From this, it may be concluded that the second duct springs from the first, and, at a later period, a new communication with

FIG. 2.



EMBRYO OF CHICK, FIVE DAYS OLD.

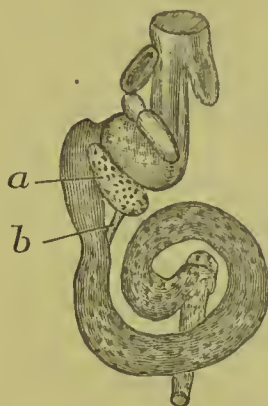
*a.* Stomach.*b.* Liver and bile-duct.*c.* Gall-bladder.*d.* Pancreas.



the bowel is established at a point corresponding to its cæcal extremity.

He has since observed the same condition in the larvæ of frogs. (Fig. 3.) It appears then established that the first and

FIG. 3.



LARVA OF FROG.

*a.* Pancreas.

*b.* Pancreatic duct.

primary duct of the pancreas is found in the rudimentary organ, and is from the beginning in communication with the bowel, while any additional ducts, whether normal or anomalous, originate in the substance of the gland and only secondarily are brought in communication with the bowel by a process of atrophy and absorption between the cæcal extremity of the duct and the intestinal wall. The existence of anomalous ducts communicating with one of the principal ducts and the intestine can be explained in a similar manner. Thus, in dogs it is uncommon to find a small duct in the gastrosplenic half of the gland, connecting the intestine at a point where the common bile-duct opens into the intestine, with the common duct as illustrated by specimen No. 28.

It is apparent that in cases of this kind obliteration of the common duct on the distal side of the anomalous or accessory duct would not interfere with the normal evacuation of the secretion into the intestinal canal. The occurrence of an acces-

sory pancreas can only be explained by the assumption that during the growth of the rudimentary pancreas, certain portions of the secreting structure become isolated by constriction and displacement, and that such portions of the gland are brought into communication with the intestinal canal by the development of an accessory duct.

### III. PHYSIOLOGY OF THE PANCREAS.

A brief consideration of the most important functions of the pancreas becomes necessary in connection with our subject, as it will serve to furnish an interpretation of some of the symptoms observed in such affections of the pancreas as interfere with the normal secretion or outflow of the pancreatic juice.

Claude Bernard, in 1848, discovered the most important function of the pancreatic juice, by observing that it exerted an emulsifying effect upon all kinds of fat. He found that by mixing fresh pancreatic juice with oil, lard, butter, or tallow, and keeping the mixture at a temperature of  $35^{\circ}$  to  $40^{\circ}$  C., an emulsion is formed almost immediately. (Schleiden and Froriep's *Neue Notizen*, vol. vii., No. 136, pp. 55, 56.) Saliva, gastric juice, bile, and blood-serum do not produce this effect. The emulsifying process takes place by the division of fat into minute globules by the pancreatic juice without converting it into a new chemical compound. The organic principle in the juice which possesses this property is very easily decomposed and precipitated by heat. Bile, with pancreatic juice, dissolves neutral as well as acid fats. Bernard ligated both pancreatic ducts in dogs, and the single duct in rabbits, and fed the animals on fat. The fat was found unchanged in the intestinal canal and the lacteals were empty. Fatty diarrhœa has been observed in a number of cases where the pancreas was the seat of extensive lesions, and the presence of this symptom should always lead the physician to make special search for additional symptoms confirming the suspicion of the existence of disease of the pancreas.

There is no dispute among physiologists in regard to the

action of pancreatic juice in transforming starch into sugar. This function was first observed by Valentin, in 1844, who experimented with an artificial fluid made by infusing pieces of pancreas in water. Bouchardat and Sankras first observed this property in the normal pancreatic secretion. The property of converting starch into sugar is possessed also by the saliva and intestinal juice; it therefore becomes an important question to determine the effect of a defective pancreatic secretion in cases where there is imperfect digestion of starchy food. It seems that cane sugar is transformed into glucose almost exclusively by the action of the pancreatic juice. This fact has received confirmation in the case of intestinal fistula observed by Busch. The fistula was located in the lower portion of the small intestine. When cane sugar was introduced in quantity into the stomach, fasting, the fluid which escaped from the upper end of the intestine contained a small quantity of glucose, but never any cane sugar. Cane sugar introduced into the fistula so that it would pass along only the lower end of the bowel, was not converted into glucose, but a large portion of it was found in the feces as cane sugar. In cases of suspected organic lesions of the pancreas it would, therefore, appear advisable to resort to feeding with cane sugar and subsequent examination of the stools for undigested cane sugar as a diagnostic measure. The presence of cane sugar in the stools would indicate that little or no pancreatic juice is secreted.

The last function of the pancreas consists in converting, with the aid of the bile and intestinal juice, the albuminoids, such as gluten, fibrin, albumen, casein, and muscine into albuminose or peptones. This latter effect of the pancreas has been doubted by a number of German physiologists, but the fact seems to be demonstrated by experiment as well as by the circumstance that the pancreas is larger in carnivorous than in herbivorous animals.

Schiff has found that the physiological function of the pancreas is at its maximum about nine hours after the ingestion of food, and at its minimum about four to six hours later. During the greatest activity of the gland the vessels become more

turgid, and can be seen with the aid of a lens between and upon the lobules, while during a state of rest they are seen only between the lobules. During digestion the gland presents a pale red color, while during rest it appears grayish-white.

The influence of the nerve-centres upon the pancreas has been made a subject of careful study by Schiff (Canstatt's *Jahresbericht*, 1861, 1-3, p. 119). Section of both pneumogastric nerves has no effect upon the circulation or secretion of the pancreas. Animals subjected to this experiment readily digested dextrine or peptones introduced into the stomach; but if ordinary food was given, no secretion took place, as stomach digestion was suspended. Total destruction of the three semilunar ganglia of the sympathetic arrests completely the secretory functions of the pancreas, even if the most favorable conditions are established by the introduction of food or injection of the products of digestion into the stomach. Wounding of these ganglia short of total destruction does not produce the same effect. Injury of the spinal cord, on a level with the eighth, ninth, or tenth rib, does not interfere in the least with stomach digestion, but promptly arrests all secretion from the pancreas, which can not be excited by food nor by the presence of dextrine in the stomach. Heidenhain has ascertained that stimulation of the medulla oblongata increases the flow of pancreatic juice as well as its active constituents. These experiments show that the reflex action of the stomach upon the pancreas is not transmitted through the sympathetic, but through the spinal cord. That the essential active principle of the pancreatic juice is necessary for digestion, has been shown by Corvisart, who found that in dogs the pancreatic juice contained, nine and a half hours after a meal, no ferment which was capable of dissolving albuminous substances. If, however, the animal was made to fast for a longer time than this, the ferment was again produced in some unknown manner. Pancreatic digestion becomes apparent six or seven hours after a meal, the time being somewhat dependent upon the duration of digestion.

The present views concerning the action of the pancreatic juice in the process of digestion may be summarized as follows:



1. Starch is converted by a diastatic ferment into dextrine and sugar, a continuation of the action of the saliva in the intestine.
2. Melted and fluid fats are emulsified by it (a property which has been assigned in a less degree to bile); at the same time, glycerine and fatty acids are formed during the process. The emulsifying process is aided by the fatty acids and alkaline salts which effect saponification (Brücke, Gad, Quincke).
3. Albuminoid substances and glue-containing tissues when mixed with an alkaline solution are dissolved and converted into peptones independently of stomach digestion (Corvisart). A portion of the peptones undergoes still further changes: as in the case of albuminoid substances, leucin, tyrosin, xanthin, and sarcin; in the case of glue, tyrosin, glycin, and ammonium may appear.

Fresh pancreatic juice obtained from the duct of Wirsung is a clear, viscid, alkaline, highly putrescible fluid, of a specific gravity of 1.030, which solidifies completely on boiling. Pancreatic juice contains: 1, albumen; 2, a number of ferments, 3, salts, especially of soda; 4, water; sometimes traces of self-digestion of the juice can be found, especially leucin (Hermann). (*Lehrbuch der Physiologie*, Berlin, 1882, p. 107.)

The pancreas secretes continually in herbivorous animals; in carnivorous, only during digestion (Heidenhain). The ferments are always present in the gland, trypsin only in a state of preparation, a so-called zymogen, which, on division, yields trypsin; this division takes place on exposure of the gland to air, the action of oxygen, very dilute alkalies, acids, alcohol, etc. During secretion the cells of the lobules are enlarged while the latter become swollen; at the same time the vessels are considerably dilated. The exact quantity of pancreatic juice secreted in man and most animals is unknown. From a practical point of view, it is important to allude to the effect of the pancreatic juice upon the skin, which it macerates, so that when the fluid remains in contact with the skin for any length of time it becomes irritated and presents a raw, eczematous surface. It also appears that the same effect is not produced when it is brought in contact with the peritoneum, because in this locality fresh pancreatic juice is removed rapidly by absorption. A positive diagnosis of dis-

ease of the pancreas will only become possible when more attention shall be bestowed upon the symptoms arising from defective digestion, the result of a defective or faulty function of the pancreas—a pancreatic indigestion. Long-continued indigestion of fatty or starchy food should be considered a sufficient indication for instituting a most careful search for pancreatic disease, by ascertaining the effect upon digestion of particular articles of diet and by examining with care the discharges from the bowels.

#### IV. EXPERIMENTS ON THE PANCREAS.

The operative treatment of injuries and diseases of the pancreas belongs to the future. Until now, the efforts of surgeons have been limited to the treatment of a few cases of cysts of the pancreas. The results obtained in these cases have been so encouraging, that undoubtedly other lesions of this organ will soon constitute new indications for surgical treatment.

The clinical material that is now available is inadequate to furnish a reliable basis for new operations; on this account it has been my object to obtain new light by subjecting the pancreas to a variety of surgical procedures, to ascertain the tolerance of this organ to direct treatment, and to determine, if possible, how much of the gland could be removed with safety in case it is the seat of injury or disease. The object of these experiments also included an attempt to elucidate some of the causes and pathological conditions of some of the well-recognized lesions of this organ.

Dogs and cats were used exclusively as objects of these experiments, as a few trials soon satisfied me that in the smaller herbivora, as the rabbit and sheep, the pancreas was proportionately small and difficult of access. The operation was always performed under antiseptic precautions, with the exclusion of the spray, and the typical orthodox dressing. The abdomen was always shaved and disinfected with a solution of corrosive sublimate, ether was used as an anæsthetic. The abdominal incision was made through the linea alba, from near the tip of the xiphoid cartilage to the umbilicus.

The omentum major was either pushed upward, or, in the majority of cases, an opening was made into it by tearing at a point opposite the external incision. The guide to the pancreas was always the pyloric orifice of the stomach—after the index finger had reached this point, it was passed along the duodenum for three or four inches, when the bowel was grasped between the index finger and thumb and brought into the incision with the pancreas. If any considerable prolapse of the viscera was made necessary to accomplish the object for which the operation was made, the exposed organs were carefully protected with a compress of gauze wrung out in a warm weak solution of corrosive sublimate (1:2000). Irrigation of the external wound and protruded organs was frequently resorted to with the same solution, to cleanse the parts of blood, and to preserve the wound in an aseptic condition. A good light and an empty stomach facilitated the operation greatly.

It was always found difficult to detach the pancreas from the duodenum without incurring a considerable and often dangerous loss of blood. To prevent this occurrence most effectively, blunt dissection and direct compression with a moist, hot, aseptic sponge, proved the most effective measures; when large vessels were to be divided double prophylactic ligation was often resorted to. After completion of the operation the pancreas and duodenum were thoroughly cleansed and dried, and the toilet of the peritoneal cavity made with care; the abdominal incision was closed with interrupted sutures introduced in the usual manner so as to include the peritoneum. The external wound was sealed with a small compress of iodoform cotton repeatedly saturated with iodoform collodium. At the end of a week the sutures were removed. Primary union of the abdominal incision was the rule, in only a few instances was healing of the wound accomplished by granulation. Ventral hernia was observed in a number of cases.



*Complete Section of the Pancreas.*

Complete section of the pancreas was made an object of experimentation, to ascertain whether the continuity of the pancreatic duct would be restored after complete division and subsequent accurate coaptation, and to study the process of repair between the divided ends of the pancreas. The section was made transversely, and, after arresting all hemorrhage, the margins of the wound were brought into accurate contact with deep catgut sutures, which were made to embrace the entire thickness of the organ.

EXPERIMENT I.—Dog, four and a half months old; weight, 35 pounds. Operation performed August 23, 1885. Complete division of pancreas transversely through the middle portion; vessels ligated with fine catgut, the hemorrhage being arterial from the gastrosplenic,

FIG. 4.



*a.* Point of section and coaptation by sutures.

Sections from M, gastrosplenic portion, show parenchyma cells in a state of fatty degeneration. Connective tissue increased.

Sections from M', duodenal portion, show normal structure. At *a*, narrow band of cicatricial tissue.

and venous from the duodenal end. Cut surfaces brought together accurately with fine catgut sutures, which were passed through the entire thickness of the organ, about one-third of an inch from the

margins of the visceral wound. Animal showed no signs of suffering or disease after the operation, but lost four pounds in weight during the first eight days. After this time the animal began to increase in weight. Highest temperature  $104^{\circ}$  F., on the fourth day. Animal killed December 6, 1885, 105 days after the operation.

An examination of the pancreas showed that union had taken place between the two ends by means of a narrow cicatrix, which was indicated by a slight constriction at the site of section. Duodenal portion of gland presented a normal appearance, as the section had been made on the splenic side of the common duct. Gastrosplenic end somewhat atrophic and sclerosed. Pancreatic duct patent to cicatrix, where the principal duct of the splenic portion was completely obliterated. No dilatation of duct in the splenic end. (Fig. 4.)

EXPERIMENT II.—Adult dog, medium size; complete section of pancreas through the junction of the middle with the splenic end. Only artery from splenic end required ligation. Immediate coaptation by means of three catgut ligatures passed through substance of gland. Animal remained well after the operation; appetite unimpaired. Dog was killed three weeks after the operation; abdominal wound completely healed; at point of section slight adhesions to neighboring organs. Visceral wound healed by a linear cicatrix of young connective tissue. Pancreatic duct completely obliterated at site of operation.

REMARKS.—These operations would tend to show that complete division of the pancreas, if not complicated by other and more serious lesions, is not a dangerous accident, if the only source of danger, hemorrhage, is met by proper surgical treatment. The coaptation of the divided ends would be desirable, but is not essential, as the continuity of the duct is not restored after this injury. No disturbance of digestion was observed in either case, as an adequate amount of pancreatic juice was secreted from the portion of the gland which remained in communication with the lumen of the intestine. As in both of these instances a greater or less amount of pancreatic juice must have escaped into the peritoneal cavity from the cut surfaces, and perhaps later from the divided duct of the splenic end, we have thus early evidence of the innocuity of extravasation of pancreatic juice into the peritoneal cavity. The process of repair

was in both instances accomplished by the interposition between the divided and coaptated ends of a linear cicatrix.

Although accurate approximation was effected by three sutures, transfixing the entire thickness of the gland by passing the needle from before backward on one side, and from behind forward on the other, it seems that primary union between the divided ends failed to take place, and that the process of repair was accomplished by connective tissue proliferation, from the connective tissue on the surface of the wound, a process necessarily accompanied by a simultaneous degeneration of the parenchyma of the gland, over an area corresponding to the seat of cicatrization.

Microscopical examination of the sections made in close proximity to the cicatrix, showed various degrees of degenerative changes in the cells of the parenchyma, with a corresponding space of connective tissue proliferation.

Complete section of the duct, even when the ends are kept in accurate coaptation, appears to result uniformly in the obliteration of the duct at the site of section. The obliteration is the direct result of the formation of a cicatrix in the lumen of the duct from the cut surfaces. In both specimens the length of the cicatrix, consequently the extent of impermeability of the duct, corresponds to the length of the cicatrix interposed between the divided ends of the gland.

The practical deductions to be obtained from these experiments are: that in transverse visceral wounds of the pancreas, the most important indication that presents itself, is to arrest hemorrhage by ligating the bleeding vessels, and to resort to suturing of the severed organ with a view to retain both ends of the pancreas as nearly as possible in their normal location, and thus maintain as nearly as possible the integrity of the vascular supply, rather than with a purpose to obtain restoration of continuity of the divided pancreatic duct, which, if it could be accomplished, would preserve the physiological importance of the detached portion of the gland. By the detached portion of the gland, I mean that portion which no longer remains in physiological connection with the intestine,

and which never regains its physiological importance after the duct has become obliterated by a cicatrix at the point of section.

### *Laceration of the Pancreas.*

Having observed that complete section of the pancreas is followed by severe hemorrhage, both arterial and venous, which undoubtedly might prove a source of no inconsiderable danger in cases of similar wounds of the organ in man, the following experiment was made to ascertain the extent of hemorrhage after laceration of this organ, without the intervention of treatment.

EXPERIMENT III.—Large adult cat ; weight,  $7\frac{1}{2}$  pounds. Abdomen opened through the median line, the pancreas exposed and detached sufficiently from the duodenum at the junction of the middle with the duodenal end, where it was torn completely across and the bleeding ends dropped into the abdominal cavity ; the wound was closed in the usual manner.

The hemorrhage was noticed to be much less than after section. Highest temperature  $104.6^{\circ}$  F., two days after operation. No symptoms of hemorrhage or peritonitis. Oct. 11, sutures were removed, the abdominal incision having apparently closed. Oct. 17, the wound opened, and it was reported that one end of the pancreas had protruded from the wound. The prolapsed viscus and wound were disinfected, the organ replaced, and the opening closed with sutures.

The animal did not appear to be very ill, but died two days later. At the autopsy no effusion was found in the peritoneal cavity and no signs of general peritonitis. A portion of the duodenum appeared gangrenous. The lacerated end of the splenic portion was adherent to the duodenum at a point two inches below the pyloric orifice of the stomach. The duodenal portion was very much atrophied and drawn up toward the splenic portion, and united to it by an extensive mass of cicatricial tissue. On opening the pancreatic duct from the duodenum, no communication could be found between it and the gastrosplenic portion of the gland.

Death in this case resulted in the accidental reopening of the abdominal wound. The prolapsed organ was, in all probability,

the duodenum and not the pancreas; the gangrene of the intestine undoubtedly was caused by the prolapse and strangulation before the bowel was replaced. The laceration of the pancreas was made at a point where the two ducts meet; hence the impermeability of the duct in the gastrosplenic portion of the pancreas. Hemorrhage was arrested spontaneously, and the process of repair, so far as the wound in the pancreas was concerned, appeared to be satisfactory. The divided ends were displaced considerably immediately after the laceration, but were subsequently brought into close contact by the cicatricial contraction.

### *Comminution of the Pancreas.*

It has been asserted by a number of authorities that dead pancreatic tissue is a highly putrescible substance, and on this account its presence is very liable to serve as a source of infection.

Believing that putrefaction can never occur without the specific germs, even in the case of dead and highly putrescible substances, the following experiments were made to test the correctness of this assertion:

EXPERIMENT IV.—Maltese cat; weight,  $3\frac{1}{4}$  pounds. Operation September 18, 1885. The pancreas, with its vessels, was completely detached from the duodenum to the extent of two inches, about the middle of the gland. The isolated portion was completely crushed between the blades of a sequester forceps. No hemorrhage whatever occurred, and the organ was dropped into the abdominal cavity. The day after the operation the temperature rose to  $105^{\circ}$  F., but the next day it was normal, and remained so until the killing of the animal, December 13, eighty-six days after the operation. No evidences of diffuse peritonitis, only slight adhesions where the gland had been crushed. The duodenal portion was atrophied and drawn toward the gastrosplenic portion, to which it was united by a firm cicatrix, which united the two ends of the gland to the duodenum, thus completing the mesenteric attachment of the bowel. The cicatrix *a*, showed a line of pigmentation throughout its entire thickness. (Fig. 5.) The crushed portion of the gland had disappeared entirely by absorption,



and its place was occupied by a firm cicatrix, which, by contraction, had approximated both portions of the gland. The crushing was done below the point of entrance of the pancreatic duct, which caused the atrophy of the duodenal portion, which was no longer in physiological connection with the duodenum.

FIG. 5.



a. Point where gland was crushed.

Sections from M show normal tissue.

Sections from M' show fatty degeneration and sclerosis.

EXPERIMENT V.—Young cat ; weight,  $2\frac{1}{2}$  pounds. Pancreas brought into the abdominal incision, with a loop of the duodenum, and without separating it from the bowel it was crushed at its middle to the extent of two inches between the blades of a sequestrum forceps. No hemorrhage followed the procedure, and the organ was dropped back into the abdominal cavity. The animal had been in bad condition before the operation, and died seven days later. At the autopsy the abdominal incision was found closed. No peritonitis or effusion. Crushed portion showed no signs of suppuration, but appeared thicker and shorter than after the crushing, a change which was attributed to the infiltration of the dead tissue by leucocytes and connective tissue proliferation. The two ends of the gland were brought into closer

contact by contraction of the recent cicatrix, which had also the effect of doubling the duodenum upon itself.

REMARKS.—In both instances the crushed parenchyma of the organ was promptly removed by absorption, which seems, in this particular locality, to proceed with unusual activity, an occurrence which can only be explained by the assumption that the peritoneum is active in this process. No infection took place, and no evidence of putrefaction could be found. Should wound infection take place in cases of this kind, there can be no doubt that the dead pancreatic tissue would serve as a most favorable soil for the septic germs, and would thus create the most essential condition for rapid and most dangerous form of infection.

These experiments also serve to demonstrate that subcutaneous crushing or comminution of the pancreas is in itself not a fatal or even dangerous injury. Subcutaneous comminution can only prove dangerous by the site of the injury, as when, for instance, the crushing takes place at or near the outlet of the pancreatic duct, where, from cicatricial contraction, obstruction of the duct takes place which would interfere with the normal escape of pancreatic juice from the intact portion of the gland. If the comminuted tissue remains in an aseptic condition, it is removed by absorption, and the loss of substance is at least partially replaced by connective tissue, which forms a bridge between the intact portions of the gland. Subsequent degeneration, atrophy, and sclerosis take place in that portion of the gland which is no longer connected with the intestine by a permeable duct.

### *Complete Extirpation of the Pancreas.*

A diversity of opinion still prevails among physiologists in regard to the immediate and remote effects of complete extirpation of the pancreas, or an artificial sudden suspension of its functions. The results obtained by different experimenters have led to diverse conclusions. Some claim for the pancreas an



essential part in the process of digestion, while others affirm with equal positiveness that the gland can be removed or rendered physiologically incompetent without impairing digestion. Bernard found that extirpation of the pancreas in birds produced death by marasmus in eight or ten days (*Mém. sur le Pancréas*, p. 157)

Berard and Colin removed the pancreas in a duck, and, on examining it six months later, found the site of the pancreas occupied by a thin layer of fat, which contained a few reddish nodules. No connection could be traced between them and the intestine. In pigs, part of the pancreas lies upon the portal vein, and the authors, therefore, removed only the portion adjacent to the duodenum. In one animal which died a few weeks after the operation from accidental causes, they found, in place of the portion of the pancreas removed, a cyst, the size of a hen's egg, which had no communication with the duodenum, and was filled with a fluid which, like pancreatic juice, was coagulated by alcohol. In a second case operated upon in a similar manner, the weight of the animal increased in five and a half months twenty-five kilogrammes. When the animal was killed, only a trace of the pancreatic duct could be discovered.

The portion of the gland left had undergone atrophy, and contained no ducts. The atrophied portion was eight to ten centimetres distant from the duodenum, and on section gave evidence of having undergone sclerosis. In five young dogs the pancreas was extirpated, leaving only that portion which lies upon the portal vein. All the animals remained well at the end of eight months. Three of the dogs were killed. In two of them the autopsy showed that the terminal extremity of the pancreatic duct remained as a blind pouch. The part of the gland left had become very much atrophied, and remained isolated from the duodenum. A glandular structure as large as a bean was found near the duodenum in both dogs; in one of them a duct connected this body with the bowel, while in the other no such connection could be traced. Taking it for granted that these small bodies were composed of pancreatic tissue, their weight being only about one-ninetieth part of the whole

gland, the amount of secretion from them would not have been sufficient to emulsify the fats. In the third dog no trace of the pancreas could be found, and yet the animal's digestion and health appeared to be normal. The feces contained no undigested fat. From these and other experiments of the same kind, the authors came to the conclusion that the presence of the pancreatic juice is not essential in the process of digestion or absorption of fat in herbivorous, carnivorous, or omnivorous animals, or in birds.

Schiff brought about complete suspension of the function of the pancreas in animals without removing any part of the organ by injecting the ducts of the gland with melted paraffin, which, at the temperature of the body, became a solid mass, completely obstructing the outlets for the secretion. Animals treated in this manner showed no signs of derangement of digestion, and were able to assimilate fat as well as healthy animals.

The following experiments were made to ascertain the feasibility of complete extirpation of the pancreas, and the effects of such a procedure upon digestion and assimilation. In all of the experiments the entire organ was removed. The hemorrhage was always profuse, and required numerous catgut ligatures for its arrest.

The larger vessels between the duodenum and pancreas were carefully isolated and removed with the gland, so that the intestine was deprived of its direct vascular supply over an area corresponding to the extent of the attachment of the pancreas.

EXPERIMENT VI.—Brown dog, four and a half months old; weight, 32 pounds. The entire pancreas was extirpated, part of the dissection was made with Paquelin's cautery. Temperature on second day 104° F., on fifth day 101  $\frac{1}{4}$ ° F. (subnormal). On the fourth day diarrhœa set in; stools contained undigested food and free fat, and on the seventh day blood. On the ninth day the animal died. During the first few days the appetite remained unimpaired, but when the diarrhœa supervened food was taken only sparingly. At the autopsy it was ascertained that the animal had lost five pounds in weight. The abdominal cavity contained a considerable quantity of bloody serum, and the peritoneum presented evidences of recent diffuse peritonitis.

The duodenum showed several dark spots on its convex surface, which might be taken for beginning gangrene. The pancreatic duct, traced from within the duodenum, was found closed at the point of section by a cicatrix upon the outer surface of the bowel.

Whether in this case the diarrhœa resulted from the absence of the pancreatic juice or from the septic peritonitis, would be difficult to determine. The duodenum had been detached from its mesentery at least ten inches, and yet the gangrene, if any, after nine days was limited to a few circumscribed patches.

EXPERIMENT VII.—Large black dog, four months old; weight, 48 pounds. Experience had proved that the separation of the pancreas and its vessels from the duodenum could be done more safely, and with less risk of hemorrhage, by tearing the tissues instead of using the scissors or knife, employing the cutting instruments only when it was thought imprudent to use too much violence in separating strong connecting bands, which would not yield to gentle force. In this case twelve ligatures were required to arrest the hemorrhage, in later experiments a much smaller number were found sufficient to arrest the bleeding, after I had learned to rely more freely on the tearing method in partial and complete extirpation of the pancreas. This dog never recovered fully from the operation and died on the fourth day, the temperature having remained subnormal during the whole of this time. At the autopsy a perforation in the duodenum was found on the convex side about five inches below the pylorus; recent peritonitis, which was undoubtedly produced by extravasation subsequent upon the perforation; gangrene of the bowel, circumscribed and limited to the seat of perforation, and a few other small spots on the convex surface of the bowel. Pancreatic duct at point of section not closed.

In this case death was directly attributable to gangrene of the duodenum, caused by the extensive detachment of its mesenteric vascular supply.

EXPERIMENT VIII.—Large adult cat. The operation occupied more than half an hour, and was attended by considerable hemorrhage from the deep attachments of the gastrosplenic end. The bleeding was

finally arrested by ligating a number of vessels in the region of the spleen. The animal never rallied from the operation and died five hours later with symptoms of hemorrhage and shock combined. On opening the abdomen no blood was found in the peritoneal cavity, except a few flat coagula which covered the denuded surface of the bowel, which extended seven inches in length.

EXPERIMENT IX.—Adult female cat. The extirpation was again attended by free hemorrhage, and the animal died half an hour after the completion of the operation, with symptoms of hemorrhage and shock.

EXPERIMENT X.—Adult black dog; weight, 33 pounds. Animal remained comparatively well for two days, when peritonitis supervened, which proved fatal on the fourth day after the operation. Wound closed; peritoneal surfaces separated with some difficulty. The abdominal cavity contained a quart of purulent fluid. At the same time, diffuse general peritonitis had given rise to extensive adhesions between the different abdominal organs. The duodenum appeared quite vascular and showed no signs of gangrene.

EXPERIMENT XI.—Medium-sized adult cat. After the extirpation of the entire pancreas, the duodenum was found on measurement to have been denuded of its mesenteric attachment to the extent of seven inches. The venous oozing proved free, and could not be completely arrested during the time which it was deemed prudent to keep the abdominal organs exposed to the atmospheric air. The animal never rallied from the operation and died two hours later. On opening the abdominal cavity, a considerable quantity of fluid venous blood was found. In this case death was caused by uncontrollable venous hemorrhage.

REMARKS.—It will be seen that of six animals subjected to complete extirpation of the pancreas, in all of them death occurred in from a few hours to nine days after the operation. The cause of death was either the primary effects of the traumatism, hemorrhage, and shock, or from secondary pathological lesions traceable directly to the operation, as may be readily gleaned from the following table :



No	Animal.	Time of death.	Cause of death.
1	Dog,	9 days,	Peritonitis.
2	"	4 "	Gangrene of duodenum.
3	Cat,	5 hours,	Hemorrhage and shock.
4	"	Half an hour,	" " "
5	Dog,	4 days,	Purulent peritonitis.
6	Cat,	2 hours,	Hemorrhage.

This table shows that the operation on cats proved more dangerous than on dogs, and of the three animals all died within five hours from the immediate effects of shock and hemorrhage. The three dogs died of peritonitis within from four to nine days. In one case the peritonitis was due to perforation, in the remaining two it was produced through either the wound or the pancreatic duct, which was found open in one of the cases. The complete extirpation of the pancreas necessitates such an extensive separation of the intestine from the mesentery, that this alone constitutes a great source of danger, as gangrene may take place. It is important to repeat that in the two specimens which showed evidences of gangrene this was observed on the convex surface of the bowel, and in neither case did it involve the entire diameter of the intestine. It requires no explanation to show that in cases of this kind the collateral circulation is established first on the concave side, where the vascular supply is nearest and the force of the circulation most vigorous. In dogs and cats the pancreas is attached so intimately and extensively to the duodenum that complete extirpation is necessarily attended by profuse hemorrhage, which often was found difficult, and in one instance impossible, to control. Ligation of some of the bleeding points was often found impossible, as any attempt in seizing the vessel necessarily grasped the muscular coat of the bowel, which it was thought to be dangerous to include in the ligature, as it might give rise to perforation. Steady pressure with a sponge wrung out of a hot, weak solution of corrosive sublimate was found to be the most reliable means in arresting troublesome oozing. None of these experiments was

sufficiently successful to study the effect of complete extirpation of the pancreas upon digestion and assimilation.

In a number of the autopsies, however, the lacteals contained a milky fluid, showing that at least a portion of the fatty food had been emulsified by other secretions. As a final conclusion, I do not hesitate to affirm that in dogs and cats complete extirpation of the pancreas is always followed by death, either from the primary effect of the operation, or the secondary consequences following it.

### *Partial Extirpation of the Pancreas.*

Partial extirpation of the pancreas implies a less degree of traumatism, and consequently less danger of causing serious nutritive changes in adjacent organs than complete extirpation, and for these reasons it is less dangerous, in a strictly surgical sense. Physiologically, a partial extirpation of the organ may imply the same consequences as complete extirpation, as when the portion of gland removed embraces the common duct or both principal ducts from each portion of the gland.

EXPERIMENT XII.—Adult cat; weight,  $6\frac{1}{2}$  pounds. Pancreas drawn into the abdominal wound with the duodenum, and separated from the bowel to the extent of two inches, at a point corresponding to the middle portion of the gland. This section of the gland, which included the termination of the ducts, was excised with Paquelin's cautery; only one artery from the gastrosplenic end required ligature; ends of gland dropped into the abdominal cavity. The temperature remained subnormal,  $101^{\circ}$  F., until the animal died, two days after the operation. At the autopsy, gangrene and perforation of the duodenum were found at a point corresponding to the site of resection.

EXPERIMENT XIII.—Scotch terrier; weight,  $25\frac{1}{2}$  pounds. Ligated pancreas at its middle, with catgut, and extirpated the gastrosplenic portion; eight ligatures were required to control the hemorrhage and about four inches of the duodenum were denuded of its mesentery. Second day after the operation the temperature was  $100.4^{\circ}$  F., which became normal ( $103^{\circ}$  F.) on third day. During the first week the

animal gained one pound in weight, showing that digestion was not disturbed by the absence of the pancreatic juice during this time.

Three weeks after the operation the dog began to lose flesh; the emaciation was progressive until the animal died of marasmus seventy-six days after the operation. During this time the appetite was not impaired, and at no time had diarrhoea been observed. The organs of the chest were found in a normal condition. The abdominal wound was firmly united. A few adhesions between the omentum and parietal peritoneum. No signs of peritonitis. The parenchyma of the duodenal portion of the gland had disappeared completely by absorption, only the connective tissue and the duct, somewhat dilated, remaining. The idea that degeneration and absorption of the parenchymatous structure of the gland were caused by local anæmia could not be entertained for a moment, as the connective tissue frame of the gland was freely supplied with numerous and large vessels. The portion of the duodenum stripped of its mesentery was repaired by a vascular strip of connective tissue, which restored the continuity of the mesenteric circulation. The common pancreatic duct was found obliterated at its point of entrance into the bowel, where it had been divided during the operation.

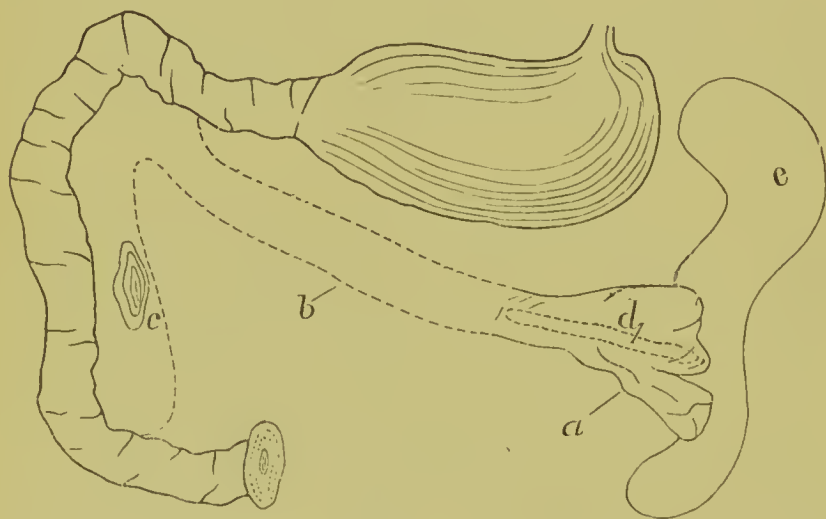
EXPERIMENT XIV.—Adult cat; weight, 6 pounds. Extirpation of gastrosplenic and half of the duodenal portion of the pancreas, with separation of duodenal mesentery to the same extent. The portion of the gland which remained was not ligated. The animal rallied from the immediate effects of the operation, but died eighteen hours later in convulsions. At the autopsy the mucous membrane of the duodenum in the portion of the bowel which had been deprived of its direct vascular supply, presented a cyanosed appearance, but no distinct signs of gangrene. Abdominal cavity contained no fluid of any kind; peritoneum normal in appearance. Slight hemorrhage between peritoneum and transversalis fascia.

EXPERIMENT XV.—Large adult dog; weight, 48 pounds. Extirpation of two-thirds of the pancreas with the common duct, leaving only a portion of the remote end of the gastrosplenic portion. The hemorrhage, which was profuse, was carefully arrested, and the pancreas ligated before section. The first two days the temperature was sub-normal, 101°–102.2° F. On the third day it became normal and remained so. The animal remained in perfect health for four weeks, when he commenced to lose flesh. Appetite voracious. No diarrhoea,



but stools contained undigested fat. Although the animal ate as much as four dogs of similar size, emaciation continued, and had become extreme when the dog was killed, 126 days after the operation. At the autopsy the abdominal incision was found adherent to the mesentery. The duodenum which had been stripped of its mesentery was found free, without a mesenteric attachment, but freely supplied with blood by two large vessels running through a band of connective tissue adherent to the bowel on the concave denuded side. The vessels were in communication with the adjacent intact mesenteric vessels, and served to complete the interrupted mesenteric circulation. The gastrosplenic portion of the gland which was left behind was found completely atrophied; in its centre the duct could be seen dilated to the size of a leadpencil, and distended by a clear, transparent fluid. The dilated duct had no communication with the bowel. (Fig. 6.)

FIG. 6.



- a.* Remnant of pancreas.
- b.* Dotted lines, outline of normal position of gland.
- c.* Connective tissue nodule.
- d.* Duct.
- e.* Spleen.

REMARKS.—As in all of these experiments the common ducts were removed with the excised portion of the pancreas, it left the animal physiologically in the same condition as after complete extirpation of the organ, as no pancreatic juice could find

its way into the intestine. In Experiments XIII. and XV. the dogs lived for a sufficient length of time to determine the influence of the pancreatic secretion upon digestion and assimilation. In both of these animals the general health and nutrition remained unimpaired for four weeks, when emaciation, with fatty stools, followed, which resulted in death from marasmus in one, after seventy-six days, and reduced the second dog to a skeleton in one hundred and twenty-six days. As from the beginning no pancreatic juice found its way into the intestine, it is difficult to account for the satisfactory condition of digestion, and the appearance of health of the animals for the first four weeks, followed by a progressive marasmus and increase of appetite. It is true that by the resection of the mesentery of the duodenum intestinal absorption was correspondingly diminished, but marasmus from this source ought to have manifested itself soon after the operation. It is now generally conceded that a healthy pancreas will absorb its own secretion in case there is any obstruction to prevent the normal escape of the pancreatic juice, and it may be that pancreatic juice entering the circulation in this manner may have some as yet unexplained action on digestion. Should this be the case, we might assume that the pancreatic tissue left behind continued to secrete until the parenchyma was incapacitated by degenerative changes to perform this function.

All of the above experiments made on the pancreas tend to prove that any portion of the gland when it becomes detached from the bowel, invariably undergoes degenerative changes, and that its parenchymatous structure disappears by absorption within a few weeks. In these cases we may safely assume that the remaining portion of the gland had been rendered physiologically incompetent during the first four weeks, the time during which the animals remained in a healthy condition. In Experiment XV. almost the entire duodenum had been suddenly deprived of its vascular supply, and yet no gangrene occurred. The collateral circulation was established by the development of two large vessels in a band of cicatricial tissue along the concave surface of the bowel, which restored the interrupted circu-

lation between the mesenteric vessels on each side of the resected portion of the mesentery. It is also important to mention that in both dogs the lacteals appeared empty at the autopsy. These experiments would then tend to prove that the pancreatic secretion is an important, if not essential, digestive fluid, and that in cases where no pancreatic juice can enter the intestine, or where the secretion is entirely suspended, digestion and assimilation become impaired, in all cases where the supposed vicarious action of other organs is inadequate to perform the functions of the extirpated or degenerated pancreas.

*Obliteration of the Pancreatic Duct by Elastic Constriction.*

A favorite method of studying the effect of exclusion of the pancreatic juice from the digestive tract has been ligation of the pancreatic duct. Against the reliability of these experiments it may be urged that in many animals the pancreas possesses more than one duct, and in some of them accessory ducts may be present, which in all probability would be overlooked in the operation, and thus complete exclusion would not be secured. In some of the smaller animals even the common duct is often found only after a prolonged and patient search, consequently any additional ducts or ductlets would be very likely to escape the attention of the operator. Rabbits have, as a rule, only one duct, which enters the intestine eight to ten inches below the pyloric orifice of the stomach; on this account the results obtained by experiments of ligating the duct have been most reliable when this animal was taken as an object for experimentation.

Amozan and Vaillard (Pancréas du Lapin, *Journ. de Méd. de Bordeaux*, April 3, 1881) tied the pancreatic duct in rabbits, and studied subsequently the histological changes in the pancreas. Animals that survived the operation, and were killed after eight days, were considerably emaciated. On examining the pancreas it was found, as in the parotid gland, after tying its duct, that an excessive amount of connective tissue had formed in and around the lobules, that the ducts were much dilated, and

the epithelial lining partly thrown off; the epithelial cells had changed in position and form, and appeared atrophied. A careful microscopical examination of the specimen showed that ligation of the duct of Wirsung produced a gradual transformation of the pancreas into connective tissue; the first effect is an enormous distention of the duct which extends to the most remote portions of the gland. The epithelial cells become detached, and with a colloid material present, lead to obstruction in the ducts. The gland cells, even as early as twenty-four hours after ligation, become translucent. After a few days the nuclei become swollen, and divide into two or three parts, which fill the interior of the cell. After seven to nine days, the place of the cells is occupied by free nuclei and round and spindle-shaped cells, which are transformed into connective tissue. In the neighborhood of some of the veins collections of colorless corpuscles could be seen. The gland, on the whole, had undergone cirrhotic atrophy.

According to Charcot and Gombault, the same cirrhotic change is produced in the liver by ligating the bile-ducts, while ligation of the ducts of the salivary glands and the ureters of the kidney produces only slight or no cirrhosis of those organs.

Bérard and Colin (*Gaz. hebdomadaire*, vi. 4, 1858) ligated the pancreatic duct in dogs which had fasted for several days, and then fed them well for twenty-four hours. The animals either showed no appetite, or, after eating, ejected the food from the stomach. If the animals were killed the lacteals were either only partially filled with a milky fluid, or, more generally, they were found empty.

The authors then tied the pancreatic duct in sixteen dogs which had fasted four or five days, and immediately injected into the duodenum a quantity of oil and lukewarm water. The animals were killed three or four days afterward, and the lacteals were found to contain a white opaque chyle both in the mesentery and walls of the intestine.

Cohnheim (*Allgemeine Pathologie*, Berlin, 1882) claims that digestion is performed in a remarkably satisfactory manner, even in case the pancreatic juice is entirely absent, in the intestinal

tract. He claims that the presence of fatty stools is the only symptom which can be positively brought in connection with a defective or total absence of pancreatic secretion. He asserts that in rabbits it is not difficult to ligate the pancreatic duct, and that in cases where this is done, with the exception of a loss of appetite for a few days, the animals suffered no bad consequences, and in a few days were as well as before the operation.

Langendorf ascertained by experiment that in pigeons a few days after obliteration of the ducts of the pancreas, the desire for food increased, but they emaciated progressively, because, as the author asserts, the carbohydrates were not digested. Cohnheim is of the opinion that in other animals the capacity of other organs to assume vicarious action is greater than in birds. Other digestive fluids perform the function of the pancreas. The transformation of starch into glucose is accomplished by the intestinal juice, and the emulsifying action of the pancreatic juice is assumed by the bile. The remnants of undigested peptones are removed by way of putrefaction induced by bacteria, which are always present in the intestinal tract. That the pancreas continues to secrete after ligation of the common duct has been demonstrated in Heidenhain's laboratory, where, thirty days after the duct had been ligated, normal pancreatic juice escaped through a canula introduced into the duct. The quantity was only slightly less than from a normal gland, and the discrepancy was readily explained, as some of the gland structures must have been destroyed by the increased pressure in the duct from the accumulated fluid. As the organ continues to secrete, and the space for accumulation is limited, the only logical conclusion which can be arrived at is that the secretion is removed by the bloodvessels and lymphatics in the gland. It has been shown by Kühne that the introduction of pancreatic juice into the circulation does not act deleteriously, as he injected one of its most active constituents—trypsin—directly into a vein without any immediate or remote ill effect upon the animal. As he detected this substance in the urine, it is reasonable to assume that the ferments of the pancreatic juice which have not been

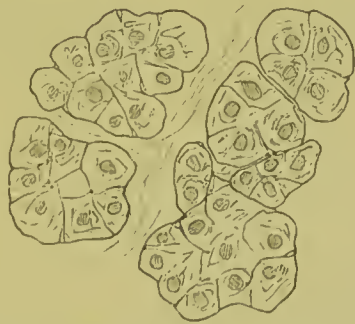


neutralized by deoxidation into the more innocuous zymogen are eliminated with the renal excretions.

The following experiments were made, not so much to determine the effect of ligation of the pancreatic duct upon digestion, as with a distinct purpose of studying the effects, in the gland and its duct, which would follow sudden obstruction in the duct. Instead of resorting to direct ligation of the duct, the same object was accomplished with greater certainty and more ease by resorting to elastic constriction by using a rubber tube or band which was made to include the entire pancreas with or without its vessels. In every instance the elastic constriction produced complete division of the organ and its duct in a short time, and the ligature was usually found encysted either at the site of application or a little distance from it.

EXPERIMENT XVI.—Adult black dog; weight, 30 pounds. Pancreas and duodenum were drawn into the abdominal incision, and a fine rubber drainage tube was passed between the duodenum and the pancreas at the junction of the middle with the proximal third, and firmly tied. The knot was kept from unfastening by transfixion with

FIG. 7.

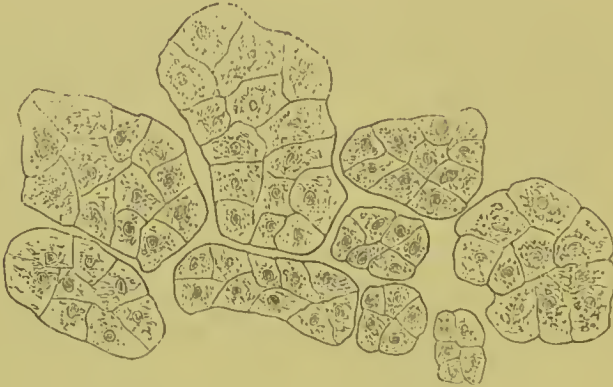


NORMAL MICROSCOPIC APPEARANCE OF PARENCHYMA CELLS FROM  
DUODENAL PORTION.

a silk ligature. The vessels were included in the rubber ligature. The animal remained perfectly well after the operation and gained three and a half pounds in ten days. The dog was killed forty-nine days after the operation. On examination it was found that the abdominal wound had healed completely; slight adhesions between

omentum and the lower portion of the cicatrix. The rubber ligature was found encysted at the junction of the middle with the proximal third (splenic end). The duodenal portion and the distal portion of

FIG. 8.



MICROSCOPIC APPEARANCE OF PARENCHYMA CELLS IN ISOLATED SPLENIC PORTION.  $\times 500$ .

the gastrosplenic end were unchanged, as the secretion could enter the intestine through the patent common duct. At the point where the ligature had been applied, the organ, with its duct, had been com-

FIG. 9.



SCLEROSIS OF SPLENIC END.  $\times 50$ .

- a.* Lobes showing fatty degeneration.
- b.* Connective tissue.
- c.* Artery.
- d.* Vein.



pletely divided, the point of section being indicated by a contraction due to cicatrization. The duct in the isolated splenic portion was slightly dilated; parenchymatous tissue in a state of degeneration; well-marked sclerosis. (Figs. 7, 8, 9.)

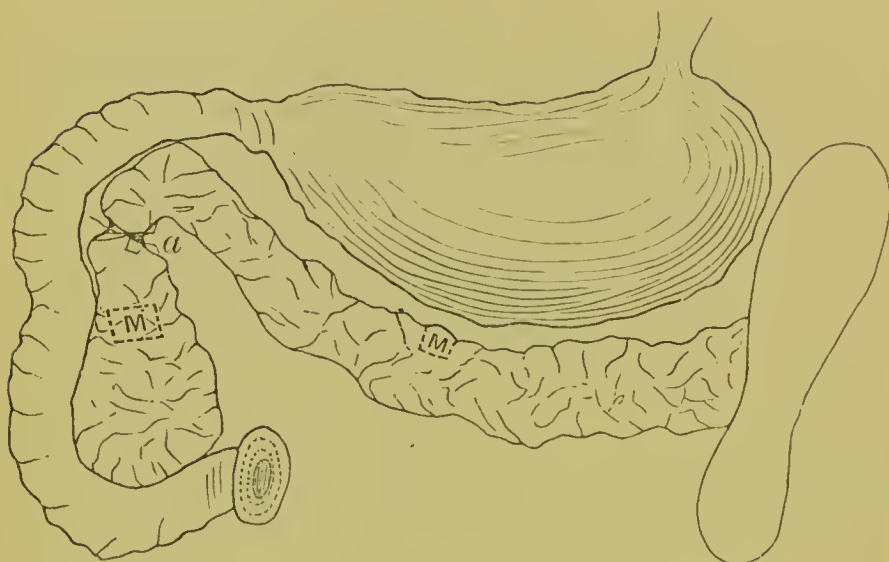
EXPERIMENT XVI*a*.—White and yellow coach dog, four and a half months old; weight, 32 pounds. In this case the rubber ligature was applied about the middle of the gland, including the artery, but not the vein. The animal remained in excellent health, and was killed ninety-eight days after the operation. At the autopsy the ligature was found encysted in a firm capsule about the middle of the gland. It had completely divided the pancreas and the duct of the splenic portion on the proximal side of the common duct. The duct in the isolated portion was considerably dilated throughout, and completely obliterated at the point of ligation. This portion of the gland had undergone parenchymatous degeneration and sclerosis, as the tissue was quite firm and grated on being cut with the knife. The portion of the gland remaining in communication with the intestine through the common duct presented a normal appearance.

EXPERIMENT XVII.—Adult black dog; weight, 20 pounds; ligation of pancreas on the proximal side of the common duct, excluding the artery. The dog remained perfectly well after the operation, gained considerable flesh, and was killed in four weeks. The rubber ligature was encysted between the duodenum and pancreas. Complete division of pancreas and duct on the splenic side of the common duct. Slight dilatation of the duct in isolated portion, with the same tissue changes as in the preceding case.

EXPERIMENT XVIII.—Adult black cat; weight, 5½ pounds. The pancreas was detached from the duodenum to the extent of three-quarters of an inch, and the rubber ligature applied so as to exclude the artery. On the second day the temperature rose to 106° F., but the general condition of the animal was undisturbed. The fever soon subsided, and digestion and nutrition were at no time impaired. The cat was killed thirty-eight days after operation. The ligature was found encysted between the pancreas and duodenum on the distal side of the common duct. Complete division of the pancreas and obliteration of the duct by a linear cicatrix. The detached mesentery was united with the bowel. The detached duodenal portion of gland had almost dis-

appeared by absorption, only connective tissue and vessels being left to indicate the contour of the gland. (Figs. 10, 11, 12, 13.)

FIG. 10.



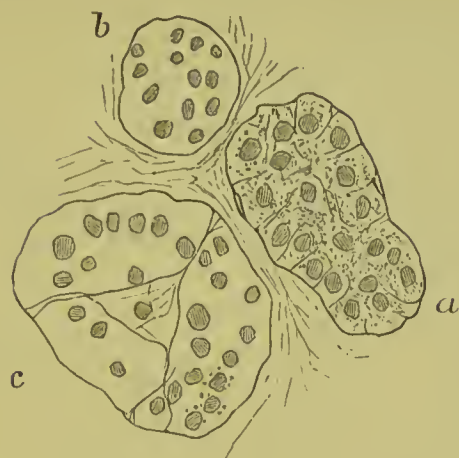
M. Point from which microscopical sections showing normal cells were taken.  
 M'. Point from which microscopical sections showing degenerated cells were taken.  
 a. Ligature.

FIG. 11.



SECTION TAKEN FROM M, SPLENIC PORTION, SHOWING NORMAL PARENCHYMA.  
 $\times 500$ .

FIG. 12.



INCOMPLETE FATTY DEGENERATION, FROM DUODENAL PORTION OF GLAND.  
 × 500.

FIG. 13.

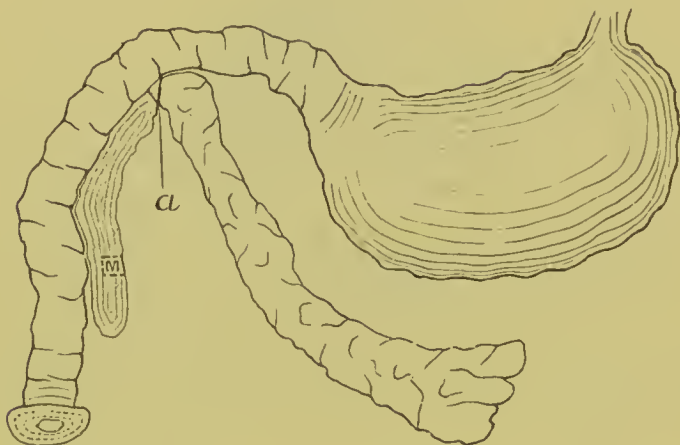


COMPLETE FATTY DEGENERATION, FROM DUODENAL PORTION OF GLAND.  
*a.* Artery.

EXPERIMENT XIX.—Adult white cat; weight,  $6\frac{1}{2}$  pounds. Detached pancreas and vessels from duodenum to the extent of an inch and a half, and applied a rubber ligature about the middle of the gland, including the vessels. Next day the temperature was  $105^{\circ}$  F.; later, normal. No disturbance of digestion or nutrition. The cat was killed eighty-five days after operation. The rubber ligature was encysted between duodenum and pancreas on distal side of the common duct. Complete section of pancreas and obliteration of duct. The duodenal portion had almost completely disappeared by absorption; the connective tissue of the gland, the dilated ducts, and the abundant vascular

supply, served to indicate the outlines of the atrophied portion. Mesentery of the duodenum was perfect. (Fig. 14.)

FIG. 14.



*a.* Ligature.

*M.* Portion taken for microscopical examination which showed complete absence of parenchyma cells.

EXPERIMENT XX.—Young black cat; weight, 2 pounds. Isolated pancreas to the extent of two inches from intestine, and included the detached portion between two silk ligatures, firmly tied. Temperature was high on second and sixth days. Animal died on sixth day. Abdominal wound was firmly united. On opening the abdominal cavity no effusion was found. No general peritonitis. Abscess between duodenum and liver; ligated portion detached, gangrenous; ligatures not encysted. Abscess in communication with pancreas. Acute atrophy of the entire pancreas. No gangrene of duodenum. In this case the suppurative process started from the portion of pancreas which had been included between the ligatures. We shall find that when infection does not take place, even isolated dead pancreatic tissue is amenable to absorption.

EXPERIMENT XXI.—Old cat; weight, 4 pounds. Detached gastro-splenic portion of the pancreas to the extent of an inch and a half from duodenum, and applied two rubber ligatures about one-half of an inch apart, including the vessels. On the following day the cat was quite ill, without any rise in temperature. For several days vomiting was the most prominent symptom. The animal died on the sixth

day. Abdominal wound united; no peritonitis; no effusion. Pancreas adherent to transverse colon: on separating the adhesion a small cyst containing about three drachms of a clear, transparent fluid was ruptured. As this cyst corresponded to the place where the ligatures had been applied, it was undoubtedly a collection of pancreatic juice which had escaped from the divided duct, and around which a connective tissue wall had formed. The ligatures had cut through the organ and duct. The ends of the gland had retracted. Duodenum healthy. Mesenteric detachment not repaired. No suppuration anywhere.

EXPERIMENT XXII.—Adult dog; weight, 39 pounds. Detached the pancreas, about its middle, from duodenum, to the extent of two inches, and applied two rubber ligatures, about one inch apart, including the vessels. On the following day the dog appeared quite sick. Increase of temperature after sixth day; no appetite, and rapid emaciation. On the ninth day, diarrhœa, which became later dysenteric in character. Died on the nineteenth day, having lost during this time six and a half pounds in weight. Abdominal wound completely united. No general peritonitis. Pancreas and duodenum adherent to liver. Portion of pancreas between ligatures gangrenous—contained in an abscess cavity. Ligatures detached and loose in abscess cavity.

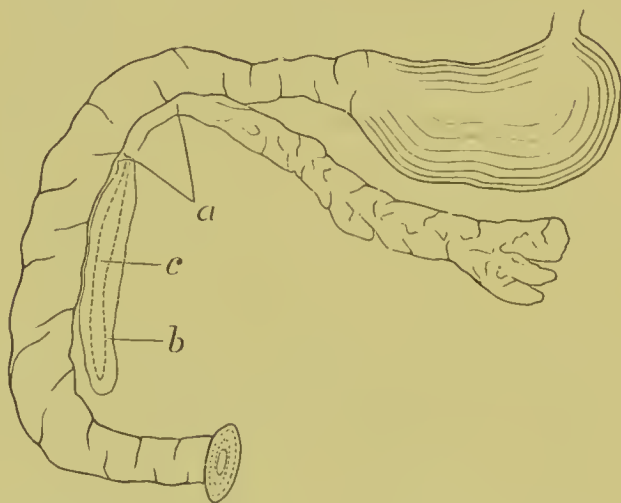
EXPERIMENT XXIII.—Adult black dog; weight, 20 pounds. Inclusion of two inches of pancreas and its vessels, after separation from duodenum, between two silk ligatures about the centre of the gland. The dog was very sick on second day, and thermometer showed an increase of temperature to 104.4° F., which continued with slight variations until the animal died on the sixth day. Wound completely united. Diffuse purulent peritonitis, and extensive adhesions. Ligated portion gangrenous and loose, with ligatures in abscess cavity between duodenum and pancreas.

EXPERIMENT XXIV.—Adult gray cat; weight, 5¾ pounds. Isolated pancreas and vessels from duodenum to the extent of an inch and a half, and included this portion between two ligatures. Animal remained well for four days, when symptoms of peritonitis appeared. Died on tenth day. Wound nicely united. No peritoneal effusion. Localized peritonitis at site of operation. Ligatures and ligated section of pancreas loose in abscess between the duodenum and pancreas. Pancreatic veins thrombosed. Duct of splenic portion in direct communication with the abscess cavity.



EXPERIMENT XXV.—Adult cat; weight, 6 pounds. Pancreas with its vessels detached from duodenum to the extent of two inches, and this portion included between two ligatures. On fifth day temperature  $106^{\circ}$  F., gradual decrease subsequently to normal. For a number of days during the febrile attack, complete loss of appetite. After this, appetite and nutrition were good. Killed twenty-eight days after operation. Portion of gland between ligatures completely disappeared by absorption. Ligatures in close proximity and encysted in firm capsule. Duodenal end atrophied, in which the dilated duct was distinctly visible. Splenic end somewhat atrophied. (Fig. 15.)

FIG. 15.



- a.* Ligatures.
- b.* Duodenal portion atrophied and undergoing fatty degeneration.
- c.* Dilated duct.

EXPERIMENT XXVI.—Large Newfoundland dog; weight, 55 pounds. Rubber ligatures made to include one inch of the pancreas about its middle, with exclusion of its vessels. Slight fever on third day, subsequently no symptoms indicating disturbance of digestion or disease. Animal killed thirty-one days after operation. Intervening portion of pancreas disappeared by absorption. Ligatures encysted. Loss of substance replaced by bridge of connective tissue. Duodenal end atrophic with dilated duct. Gastrosplenic portion normal in appearance, and in direct communication with the intestine through the common pancreatic duct.

Only two of the animals recovered after isolation and double ligation of the pancreas, a fact which shows the great danger of leaving in the abdominal cavity pancreatic tissue not supplied with blood. We can only assume that the danger of infection is increased by leaving an exceedingly favorable culture substance for infective germs in the abdomen. If the operation is perfectly aseptic, the dead pancreatic tissue remains aseptic, and is removed in an exceedingly short time by absorption.

EXPERIMENT XXVII.—Large adult cat. Applied a single rubber ligature on distal side of the common pancreatic duct, excluding the artery and vein. No disturbance of digestion or nutrition, and temperature normal throughout. Animal, when killed twenty-eight days

FIG. 16.



POSTERIOR VIEW.

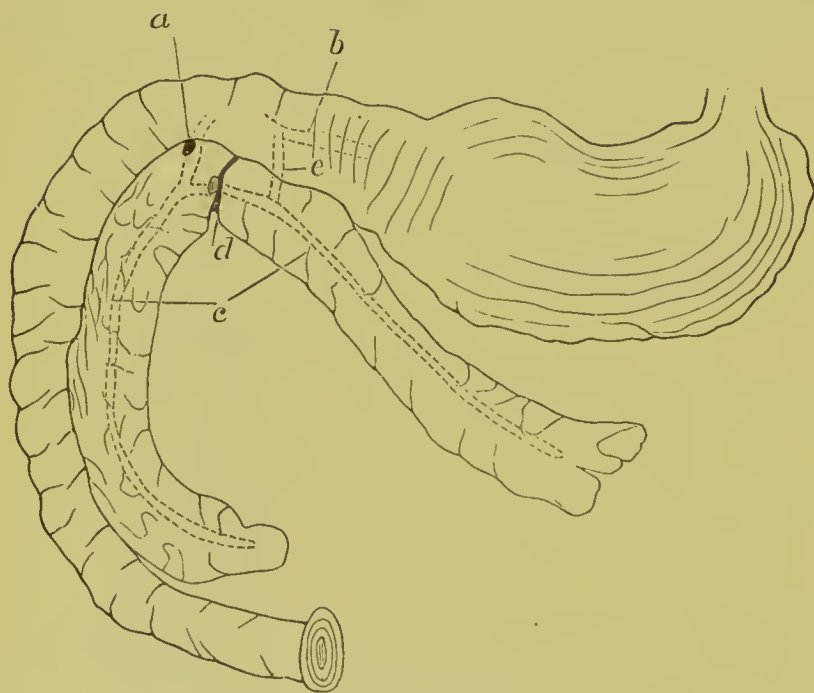
- a.* Common duct.
- b.* Ligature.
- c.* Duodenal portion, atrophy and fatty degeneration marked, duct dilated.
- d.* Liver, pancreas adherent to.

after operation, had grown fat. Only a few slight adhesions at site of ligation. Pancreas and duct were completely divided by the ligature, the ends kept in contact by a linear cicatrix. Ligature was encysted between the duodenum and under surface of the liver. The gastro-

splenic portion of the pancreas was normal in appearance, and connected with the common duct. The duodenal portion was atrophied; the duct slightly dilated. (Fig. 16.)

EXPERIMENT XXVIII.—Large Newfoundland dog. Ligation of the pancreas and its vessels with a rubber ligature on the proximal side of the common duct. No fever, no disturbance of digestion or nutrition. Animal was killed ninety-one days after operation. On opening the abdominal cavity, the entire pancreas presented a normal appearance in size, shape, and consistence. Where the ligature was applied a narrow constriction was visible, which represented the point of section

FIG. 17.



- a.* Duct of Wirsung.
- b.* Ductus choledochus.
- c.* Main pancreatic ducts.
- d.* Ligature.
- e.* Accessory duct.

made by the ligature. Ligature was encysted in the cicatrix. On tracing the pancreatic duct from the interior of the intestine, a probe could be passed along the duct of the duodenal portion. On following the duct of the splenic portion, the probe was arrested at the cicatrix,

about a quarter of an inch from the wall of the intestine. The duct at this point was completely obliterated. As in all of the previous experiments the detached portion of the gland had invariably become the seat of degenerative changes and atrophy, I was at a loss to account for the normal appearance of the gastrosplenic portion of the gland in this instance. After a prolonged and careful search a minute opening was detected in the fold of the mucous membrane surrounding the outlet of the bile-duct, and by careful manipulation a delicate probe was passed along a canal which passed obliquely through the wall of the bowel, entered the pancreas on the splenic side of the ligature, and terminated in the large duct of the gastrosplenic portion. (Fig. 17.)

The explanation for the absence of atrophic changes had been found. An accessory duct had furnished an outlet for the secretion in the gastrosplenic portion, and had maintained the physiological connection between this portion of the gland and the duodenum after obliteration of the common duct of the gastrosplenic portion. It was the only instance where such a structure was detected, and the only specimen in which the normal structure of the detached portion of the gland was preserved after obliteration of the principal duct.

REMARKS.—These experiments illustrate the feasibility of ligation of either portion of the pancreas near the common duct as a surgical procedure, and the regularity with which the pancreatic tissue is removed by degeneration and absorption in the detached portion of the gland. By physiological detachment, I mean again a permanent interruption to the escape of secretion by section or obliteration of the duct.

After ligation of the duct or gland, secretion continues, and as the space for accumulation of the fluid is limited, a certain degree of pressure within the duct is established, as is evident from the uniformity with which the ducts throughout that portion of the gland were found dilated. In no instance, however, was anything observed which resembled a cyst. The dilatation was not limited to any particular portion of the duct, it always presented itself as a uniform ectasia of the entire duct. We can only explain the moderate dilatation by assuming that, as soon as a certain degree of pressure is reached, the pancreatic juice is removed by absorption by the vessels and lymphatics of the

pancreas, and that a greater accumulation of fluid and distention of the duct could only occur when this function has become diminished or suspended by organic changes in the structures which are concerned in the removal of the secretion. The atrophic changes in the parenchyma of the detached portion of the gland have been ascribed to the pressure within the ducts upon the parenchyma cells—a sort of pressure atrophy.

This supposition lacks proof, inasmuch as the pressure at any time could not have been considerable, and as the same atrophic changes have been observed in cases where no pressure could have existed, as in cases of external and internal pancreatic fistula, where the duct remains open until secretion ceases. The atrophy can also not be due to deficiency of blood supply, as it occurred regularly and as rapidly in cases where the blood supply remained unimpaired; and in many of the specimens, illustrating complete atrophy, the abundant vascular supply was distinctly observed and noted. I am unable to furnish a satisfactory explanation of the cause of this form of atrophy. All that I can say is, that in every instance in which complete physiological detachment had been produced by ligation, resection, crushing, or any other means, this result followed without exception.

Practically this observation is of great importance, because it demonstrates that in operations upon the pancreas it is not essential or necessary to remove peripheral portions of the gland, for fear that if any of the parenchymatous structure should remain a retention cyst would follow. In partial resections for injury or disease it would be advisable to ligate the peripheral portion, and permit it to remain, as it would lessen the danger by the infliction of less traumatism, and we can confidently expect that it will be removed in a short time by absorption.

These experiments settle definitely an important pathological question. It has been claimed by all writers that cysts of the pancreas are produced by obstruction of the common duct. In most of the specimens which have been examined, it is distinctly stated that the obstruction was not complete, as, for instance, in



cases of impaction of pancreatic calculi when found in connection with cysts. In all of these experiments obstruction of the duct was sudden and complete by the elastic constriction, and subsequently permanent by the formation of a cicatrix between the divided ends of the duct.

In none of the specimens, where life was sufficiently prolonged, did the process of obliteration fail to take place, and yet in none of them was even an attempt at the formation of a cyst observed.

The experiments with the double ligature teach the importance of removing such portions of the pancreas as are not supplied with bloodvessels, rather than trust to the doubtful expedient of leaving them to be removed by absorption, as dead pancreatic tissue is an exceedingly putrescible substance, and furnishes the most favorable conditions for the growth and increase of septic germs.

#### *External Pancreatic Fistula.*

The formation of a permanent pancreatic fistula has always constituted one of the most difficult tasks in experimental physiology. Bernard (*Leçons de physiol. expér. appliquée à la médecine*, t. ii., Paris, 1855), after many fruitless attempts, declared that it was impossible to establish a permanent pancreatic fistula, for the reason that the canula invariably fell out after a few days, after which the duct again conveyed its contents into the duodenum. He found, also, that the pancreatic juice which flowed from the fistula remained normal for only twelve or sixteen hours, after which time it became thinner, and did not coagulate on the application of heat. Neither did it possess any longer the property of decomposing fat into glycerine and fatty acids. This change in the pancreatic juice always appeared as soon as inflammation was noticed about the seat of operation. In horses and cattle this condition appeared so early, that it was found impossible to obtain pure pancreatic juice from a fistula.

The intermittent action of the pancreas is well illustrated

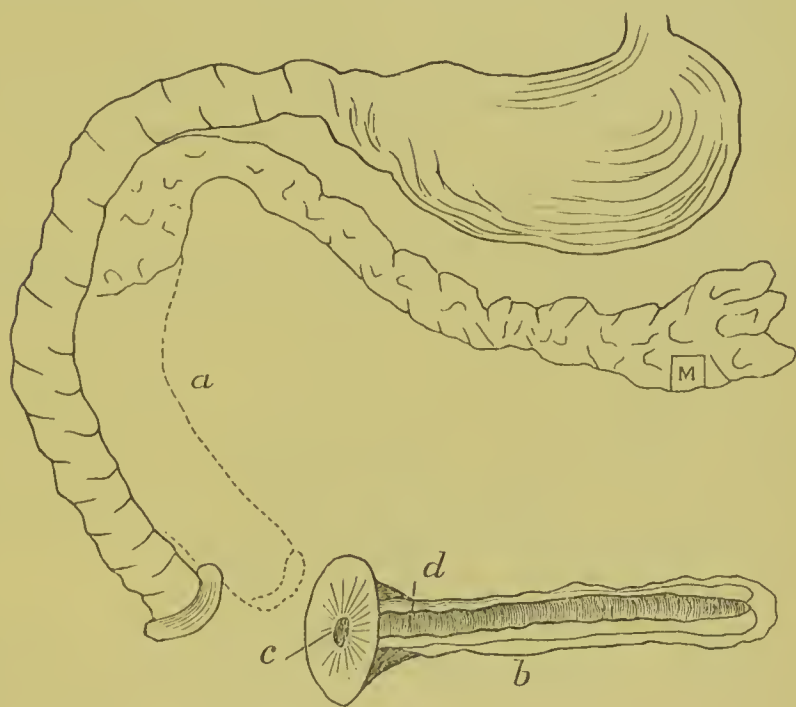
in animals when a fistula has been established, active secretion taking place only during digestion. Bernard ascertained that in medium-sized dogs, in an hour, not more than five or six grammes of juice could be obtained. Ether injected into the stomach increased the secretion, while vomiting suspended the flow of fluid, but not its secretion, since just after the act it was poured out in so much greater quantities. Pressure on the abdomen and the respiratory movement of the chest accelerated the flow from the fistula.

The following experiments were made for the distinct purpose of studying the functional activity of a detached portion of the pancreas, consequently a different method of operating had to be devised. Having satisfied myself that physiological detachment of a portion of the pancreas by section, resection, or ligation always results in degeneration of the parenchyma, and atrophy of the detached portion, I determined to study this subject more thoroughly by interrupting all anatomical continuity between the detached and the principal portion of the gland. An external pancreatic fistula was established by bringing the pancreas with the duodenum into the wound, ligating the pancreas usually below the common duct, dividing the gland and its vessels completely on the distal side of the ligature, arresting carefully the hemorrhage from the cut surface without interfering with the principal duct, detaching the distal, or duodenal portion sufficiently from the bowel, so as to bring the cut surface a little above the level of the outer surface of the wound, where it was fixed with four catgut sutures to the margins of the wound. The remaining portion of the wound was closed in the usual manner. This method secured a permanent pancreatic fistula, the outflow from which would indicate the amount of secretion from the detached portion of the gland.

EXPERIMENT XXIX.—Young dog; weight, 30 pounds. Ligated pancreas at junction of middle with distal portion, section of gland immediately below ligature, separation of detached portion from duodenum to the extent of two inches, implantation of free end into

the lower angle of the abdominal incision with four catgut sutures. During the second day, slight rise in the temperature. During the first day the dog refused to eat, and no pancreatic juice was seen to escape from the cut surface of the gland. The second day the secretion was copious, resembling normal pancreatic juice. The discharge was intermittent, most copious a few hours after eating, and entirely absent when the animal fasted. At the end of the first week, the secretion became less in quantity, and gradually continued to decrease

FIG. 18.



- a.* Point of division of gland.
- b.* Portion of gland planted into wound, showing complete atrophy.
- c.* External cicatrix.
- d.* Dilated duct.
- M.* Portion taken for microscopical sections, showing normal structure of gland.

until it ceased entirely on the twenty-first day. The portion of the pancreas included in the wound became smaller from day to day, and appeared to have disappeared almost entirely when the secretion ceased, leaving at this place an irregular depressed cicatrix, with no tendency to hernial protrusion. The animal remained in perfect health and was killed seventy days after operation. At the autopsy, the cut end of

the atrophic duodenal portion of the pancreas was found adherent to, and incorporated in the firm cicatrix of the abdominal wound. The parenchyma in the detached portion of the gland had disappeared completely; in the centre of this portion the principal duct could be seen dilated to the size of a lead-pencil, and it contained a clear, transparent fluid. The duct could be traced to the peripheral extremity of the gland in one direction, and into the cicatrix of the abdominal wound in the other. The atrophic portion of the gland was freely supplied with bloodvessels. The duct was widest near the cicatrix, and gradually tapered toward the end of the gland. The cut proximal end had become adherent to the duodenum. A probe could be passed from the duodenal end of the common pancreatic duct along the entire distance of the splenic portion; the point of section had evidently been made on the peripheral side of the common duct, through the duodenal portion of the gland. (Fig. 18.)

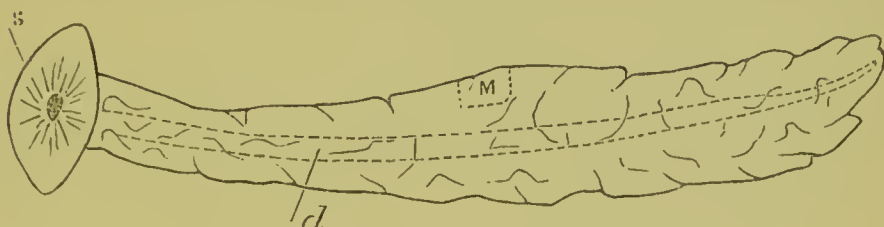
EXPERIMENT XXX.—Adult cat; weight, 5 pounds. In this case the gland was divided near the middle. The duodenal portion was detached from the intestine to the extent of two inches, and sewed into the lower angle of the incision. Second day temperature, 105.8° F. The animal took but little food, and only a very small amount of secretion was observed to escape from the duct on the cut surface of the gland. The cat died on the third day, after the temperature had shown an increase to 106° F. At the autopsy it was shown that death had resulted from purulent peritonitis, and croupous pneumonia of right lung. No gangrene of duodenum or pancreas.

EXPERIMENT XXXI.—Adult cat; weight, 5¾ pounds. Operation same as before. The animal was quite ill for three days; at the end of this time the temperature was 104.8° F.; took but little nourishment. From this time improvement took place, and finally complete recovery. Escape of pancreatic juice was first observed on second day; it gradually increased for three days, when it began to diminish and ceased completely on the seventeenth day, when the wound closed completely, showing no tendency to ventral hernia. Unfortunately the animal was lost on the forty-eighth day.

EXPERIMENT XXXII.—Black shepherd dog; weight, 43½ pounds. Ligation of pancreas about its middle, double ligation of pancreaticoduodenal artery, division of gland, application of four ligatures to arrest

hemorrhage from the distal portion of the gland, detachment of duodenal end to the extent of two inches from intestine, and fixation of free end into the lower angle of the incision by four catgut sutures. No

FIG. 19.



EXTERNAL PANCREATIC FISTULA.

*s.* Portion of skin with external cicatrix in centre.

*d.* Dilated duct.

*M.* Portion taken for microscopical examination, showing advanced fatty degeneration of parenchyma, and sclerosis throughout entire transplanted portion of gland.

untoward symptoms after operation. Free escape of pancreatic juice at the end of the second day, which continued quite profuse for ten

FIG. 20.



EXTERNAL PANCREATIC FISTULA, FROM DUODENAL PORTION OF GLAND.

Some of the acini completely empty, others show groups of cells in advanced stage of fatty degeneration.

days during digestion, when it began to diminish, and ceased entirely on the twenty-fifth day after the operation. During the first six days the animal lost four pounds in weight, after this time digestion and



nutrition were perfect. The dog was killed forty-six days after operation. Post-mortem appearance was almost identical with that in Experiment XXIX., except that the duodenum was found adherent to the under surface of the liver. The vascularity of the atrophic duodenal end was particularly well marked. (Figs. 19, 20.)

REMARKS.—These experiments have demonstrated conclusively that when a portion of the pancreas is detached by complete section, secretion continues until, by degeneration and absorption, the parenchyma of the gland has disappeared. The degeneration evidently commences at the end of eight to twelve days, and progresses rapidly and continuously until the end of twenty to twenty-seven days, when all of the secreting structures have lost their physiological function, as indicated by a permanent cessation of the flow of pancreatic juice. The existence of distention of the principal duct in these cases can only be explained by assuming that it occurs after closure of the fistula has taken place by an accumulation of secretion from the lining of the duct, or that the dilatation is caused by traction upon the outer surface of the duct by the connective tissue framework of the gland, or the contraction incident to interstitial connective tissue proliferation. That the atrophy in the part of the organ which had been detached from its connections with the intestine was not due to a traumatic interstitial pancreatitis is proved by the normal appearance and structure of the remaining portion of the gland which had retained its anatomical and physiological relations to the intestine. I am, therefore, again supported in the assertion that physiological detachment of any portion of the pancreas is invariably followed by degeneration and complete atrophy, consequently also by complete cessation of functional activity.

#### *Internal Pancreatic Fistula.*

It is a well-known fact that when pancreatic juice is brought in contact with the skin it produces irritation, an effect which has been attributed to its digestive qualities. In all the animals where an external pancreatic fistula was established, the skin

appeared sore and macerated as far as it had been kept moist with the pancreatic juice.

Clinical observation has shown that in nearly all cases where a cyst of the pancreas was treated by the formation of a pancreatic fistula the skin around the fistula remained in an eczematous condition so long as the fistula continued to discharge fluid. Taking these facts into consideration, we should naturally anticipate that when pancreatic juice is brought in contact with the peritoneum it will produce a destructive effect upon it by its digestive properties, or it may be even followed by diffuse peritonitis.

In opposition to this reasoning, Bernard informs us that none of his animals died when he had made a pancreatic fistula, and as in these cases extravasation of pancreatic juice into the peritoneal cavity was almost inevitable, it would appear that its effects here are not so disastrous as when it acts upon the skin. Concerning this point, Heidenhain remarks :

“The animals do not suffer from this circumstance, as the duct is regenerated in spite of the wounded surface being bathed in the secretion. Nevertheless, it is difficult to explain this. Why do not the wounded and suppurating tissues undergo digestion by the pancreatic juice? The efficacy of the albumen ferment is destroyed in some way, I presume, probably by being converted into zymogen, the living tissues having the same effect on the juice as Podolinski observed, by treating the pancreatic juice with powdered zinc or yeast ferment.”

As pancreatic juice, when brought in contact with the atmospheric air, may undergo rapid changes, and thus render it abnormal, experiments made with it by injecting it into the peritoneal cavity would not represent the action of normal pancreatic juice upon the peritoneum, hence the results obtained would not represent the effects of normal secretion. To determine the effect of normal pancreatic juice on the peritoneum, I resorted to the formation of an internal pancreatic fistula, so as to bring the peritoneum in contact with the normal pancreatic secretion as it escapes from the cut surface of the gland. My experiments with external pancreatic fistula had taught me that

the isolated portion of the gland continued to secrete for seventeen to twenty-six days; hence, I was convinced that if I could establish the same conditions within the peritoneal cavity, I would secure an intermittent flow of normal pancreatic juice into the peritoneal cavity for the same length of time. The operation was performed in precisely the same manner as for external fistula, except that the cut end of the duodenal portion was detached from the duodenum, turned downward, and dropped into the peritoneal cavity.

EXPERIMENT XXXIII.—Young dog; weight,  $31\frac{1}{2}$  pounds. Section of pancreas near middle, detached duodenal end from bowel to the extent of three inches, turned it downward, and closed the abdominal wound completely. Second day, temperature  $106^{\circ}$  F.; slight tympanites. Dog appeared quite ill for a number of days, and temperature remained above normal for a week, though the animal remained in good condition until killed, seventy-six days after the operation. The autopsy showed evidences of a former local peritonitis at the site of operation; the duodenal or detached end of pancreas was completely atrophied, its ducts dilated, closed, and adherent to duodenum. Splenic portion normal in size and appearance; cut end adherent to duodenum; common duct pervious.

EXPERIMENT XXXIV.—Adult dog; weight, 21 pounds. Detached pancreas from its middle toward distal side to the extent of five inches. Divided the pancreas with Paquelin's cautery, between two compression forceps; used no ligatures. Turned end of lower portion downward, and closed the abdominal incision. Animal died on the third day, with symptoms of peritonitis. No rise in temperature. Post-mortem examination showed evidences of diffuse purulent peritonitis; no hemorrhage, no sign of gangrene of duodenum.

EXPERIMENT XXXV.—Adult dog; weight, 37 pounds. Ligated pancreas on distal side of common duct. Divided the gland transversely just below ligature, tied vessels with catgut, detached duodenal portion from intestine to the extent of three inches, turned the free end downward, and closed the abdominal incision. Temperature remained normal, but the animal was reported sick for five days, when recovery set in, and the dog remained in good health as long as he was under observation—thirty-two days, when he ran away.

EXPERIMENT XXXVI.—Adult cat; weight,  $5\frac{1}{4}$  pounds. Applied ligature below common pancreatic duct, and divided the gland on distal side of ligature, detached duodenal portion from intestine to the extent of two inches, turned the free end downward, and closed the abdominal wound. The animal remained well after the operation, and was in good condition when killed eighty-three days after the operation. Great omentum was adherent to lower border of liver; mesentery adherent to duodenum; duodenal portion of gland completely atrophied; cut extremity of splenic portion adherent to duodenum by a firm cicatrix just below the entrance of the common duct into the intestine. This portion of the gland was normal in size and appearance. Atrophied portion was abundantly supplied with blood-vessels.

EXPERIMENT XXXVII.—Adult cat; weight,  $5\frac{1}{2}$  pounds. Pancreas was ligated just below the common duct, transverse section of the pancreas below ligature, detached the peripheral portion to the extent of an inch and a half, turned the free end downward, and closed the abdominal incision. Death on third day. No hemorrhage into the abdominal cavity; diffuse purulent peritonitis; adhesions between the duodenum, liver, and greater omentum.

EXPERIMENT XXXVIII.—Young cat, same operation as in Experiment XXXVII. No serious symptoms were observed after the operation. About two weeks later progressive emaciation, until the animal died forty-two days after operation. At the post-mortem, an extensive abscess was found underneath the skin over the sacrum. Some evidences of previous peritonitis, but no effusion or suppuration. Duodenal or detached portion quite vascular, but in a condition of advanced atrophy. Splenic portion was normal in size and appearance, but cut end was firmly adherent to the duodenum below the entrance of the common duct.

EXPERIMENT XXXIX.—Young cat. Operation the same, followed by no serious symptoms and no rise in temperature. Animal was killed seventy days after the operation. At the autopsy, the lower border of liver was found adherent to the cicatrix of the abdominal wound. Duodenal portion was completely atrophied. At the point where the duodenum was denuded of its mesentery, the bowel had become acutely flexed by cicatricial contraction which approximated the raw surfaces. The same cicatrix connected the atrophied and intact portion of the pancreas.



EXPERIMENT XL.—Adult cat. Pancreas detached from duodenum to the extent of an inch and a half, otherwise operation same as in preceding cases. Rise in temperature on fourth and seventh day, otherwise the animal was in good condition. Killed forty-two days after the operation. Animal was well nourished. Great omentum adherent to cicatrix of wound. At the point where the gland was detached from the duodenum, the bowel doubled upon itself acutely, the raw mesenteric surfaces being in direct contact. The connective tissue remnant of the duodenal portion was incorporated in this cicatrix but could be readily identified. Cut surface of splenic end was firmly adherent to the duodenum below the entrance of the common duct; presented normal appearance in size, structure, and shape.

EXPERIMENT XLI.—Young cat. Operation the same as in preceding case. Temperature on fifth day, 105.5° F. Animal was killed on seventh day: wound not completely healed; abscess on concave side of the duodenum; no peritoneal effusion or signs of general peritonitis.

EXPERIMENT XLII.—Adult dog; weight, 13 pounds. Operation same as before, mesenteric denudation of duodenum two inches. From second to eighth day slight rise in temperature. Animal in excellent condition when killed thirty-five days after operation. Small ventral hernia. A number of adhesions at site of operation. Mesenteric circulation at point of detachment restored by a plexus of new vessels, contained in a narrow band of cicatricial tissue. Duodenal portion almost completely absorbed, only a few scattered imperfect lobules visible. Splenic end normal and in communication with duodenum through common duct.

EXPERIMENT XLIII.—Adult dog; weight, 15 pounds. Operation same as in preceding experiment. No disturbance of digestion or nutrition, and no rise in temperature. Animal was in good condition when killed thirty-five days after operation. Duodenal portion indurated and contracted into a hard string which contains a dilated duct. Liver adherent to diaphragm. Duodenum without a proper mesentery over a space of several inches, vascular supply furnished by new vessels passing along the surface of the bowel on the concave side. Examination showed that ligature had been applied on splenic side of duct, and that the section had probably been made near or through the common duct, as the splenic portion was also in a state of advanced atrophy and not in communication with the bowel. The duodenal



portion was in a state of extreme atrophy, much shortened, and firmly adherent to the bowel. Just below point of operation, a small encapsulated abscess was found on the convex side of the bowel.

In this case no pancreatic juice could gain entrance into the bowel, and yet digestion and nutrition appeared to be unimpaired.

No.	Animal.	Time of death	Cause of death.
1	Dog,	76 days,	Purulent peritonitis.
2	"	3 "	Killed.
3	"	Living,	Ran away 32d day.
4	Cat,	83 "	Killed.
5	"	3 "	Purulent peritonitis.
6	"	42 "	Abscess in sacral region.
7	"	70 "	Killed.
8	"	42 "	"
9	"	7 "	"
10	Dog,	35 "	"
11	"	35 "	"

REMARKS.—As in cases of external pancreatic fistula the secretions amounted often to more than four ounces a day, we have every reason to believe that the same quantity was secreted and discharged into the peritoneal cavity in the cases in which an internal pancreatic fistula was established. The effect, if any, of the pancreatic juice upon the peritoneum can be seen best by an examination of the preceding table.

In only two of the eleven experiments was death caused by purulent peritonitis. In one a circumscribed abscess was found in the concavity of the duodenum, and in one animal a small abscess, with thick walls, was found on the convex surface of the duodenum, which did not give rise to any symptoms during life. One of the cats died from the consequences of a large abscess over the sacrum forty-two days after the operation. The post-mortem appearances in the abdomen pointed to only a very circumscribed peritonitis at the seat of operation. As the mortality after the formation of an internal pancreatic fistula did not exceed the death-rate of any other form of operation upon the pancreas, we are justified in the assertion that normal pancreatic juice when brought in contact with the peritoneum does not produce peritonitis.

Another question which presents itself is this: What becomes of the pancreatic juice in the peritoneal cavity? No mention is made in the autopsy records of these cases, of the presence of any kind of effusion in the peritoneal cavity, except in the two cases where death resulted from purulent peritonitis, when the abdomen contained a considerable quantity of a sero-purulent fluid thrown out by the inflamed serous membrane. From these evidences we can only arrive at the legitimate and logical conclusion that normal pancreatic juice is promptly and rapidly removed by absorption when brought in contact with the peritoneum. The uniformity with which the detached portion of the pancreas was found atrophied, only corroborates the statements previously made when we considered the same question in connection with external pancreatic fistula. Another incidental observation of considerable importance was made concerning the danger of gangrene of the duodenum in case the mesentery is detached to any considerable extent.

In all of these experiments the duodenum was denuded of its mesentery, and consequently deprived of its direct vascular supply to the extent of from one to three inches, and yet in no case was the duodenum found gangrenous. As in other experiments upon the pancreas, the duodenum showed a marked immunity against gangrene from interruption of its vascular supply. The last experiment is of great importance, as it illustrates that digestion may remain unimpaired even if no pancreatic juice is produced, or in the event of its secretion not gaining entrance into the intestine on account of complete and permanent obliteration of the common or principal pancreatic ducts. The ligation experiments, as well as the internal pancreatic fistula, also corroborate the statement made by some authors, that the introduction into the circulation of normal pancreatic juice is innocuous, and that this abnormal supply is tolerated for two weeks or more without any appreciable ill consequences.

## V. WOUNDS OF THE PANCREAS.

Of all abdominal organs the pancreas is most exempt from injury, both from direct and indirect violence, a circumstance which is entirely due to its remote location, and the ample protection furnished by the vertebral column and the bony walls of the chest. The anatomical relations of the pancreas to numerous and important organs are such that when this organ is injured the same violence which has produced the injury has also wounded an adjacent and perhaps more important viscus. The frequency with which such grave complications attend wounds of the pancreas, and the profuse hemorrhage which usually attends such injury, are elements of danger which impart to wounds of the pancreas more than an ordinary degree of gravity.

*Contusion.*

CASE I.—Cooper (*Lancet*, Dec. 31, 1839, vol. i. p. 486) reports the case of a man, aged thirty-three years, run over by a light cart, moving with great speed. No marks of external injury were visible, but the lower left ribs were fractured, and the pancreas was literally smashed, and embedded in semi-coagulated blood. The spleen and left kidney were also ruptured. He died a few days after the accident.

CASE II.—Travers (*Lancet*, 1827, vol. xii. p. 384) observed a case of laceration of the pancreas at St. Thomas's Hospital. An intoxicated woman was knocked down by the wheel of a stage-coach, which, however, did not pass over her. She lived only a few hours. Several ribs were fractured; the pancreas was found completely torn through transversely, the liver was lacerated, and much blood was effused.

CASE III.—Störck (*Annus Medicus*, 1836, p. 244) mentions the case of a woman who was run over by a coach, and who died within a few hours. The pancreas was found completely torn in two, and embedded in a large mass of semifluid blood. Several ribs were fractured, and the liver was also ruptured.

CASE IV.—M. Le Gros Clark (*Lect. on Princ. Surg. Diag.*, 1870, p. 298) observed an instance of subcutaneous laceration of the pancreas,

which occurred in a lad who was also the subject of other severe injuries that speedily proved fatal.

*Penetrating Wound of Abdomen, with Protrusion of Pancreas.*

CASE V.—Laborderie (*Gazette des Hôpitaux*, 1856, No. 2) reports the case of a girl, aged ten years, who had fallen, while running, upon an open pocket-knife, which inflicted a wound two centimetres below the lower border of the rib, and three fingers' breadth to the right of the median line, extending outward for one and a half centimetres, almost horizontal, with a little inclination from above downward. The pancreas was found strangulated in the wound so tightly that not a drop of blood escaped. The author believed that the prolapse was caused by the screaming of the patient. The duct of Wirsung and vessels escaped injury. The abdomen was painless on palpation, and there were no signs of internal hemorrhage. The knife had entered the abdomen under the lobus Spigelii of the liver, and in its course reached the stomach, cut through the gastrohepatic omentum, and then penetrated between the liver and pylorus to the pancreas, without injuring any of the many large vessels in the locality through which it passed. An attempt to replace the gland was only partially successful. The mass was transfixed and tied at its base with a double ligature, and the portion outside of the ligature removed with the knife. After this procedure nausea and vomiting set in, which, however, soon subsided. The wound was treated by the use of cold water applications. On third day the patient complained of being chilly, and the abdomen became somewhat tympanitic and tender on pressure. These symptoms soon subsided, and the ligatures sloughed through, leaving a granulating surface, which healed in fourteen days. Recovery was complete in three weeks.

Hyrtl and Klebs are incredulous as to the prolapse of the pancreas in this case; they believe that the mass which was ligated and removed was not the gland, but a portion of the omentum. Nussbaum (*Die Verletzungen des Unterleibes*, 1880), however, in speaking of visceral injuries of the pancreas, states distinctly that in penetrating wounds of the abdomen in the region of the pancreas, this organ manifests a tendency to

prolapse, and that this circumstance facilitates the treatment, as it protects the peritoneal cavity against infection by plugging the wound, and at the same time affords better access to the bleeding vessels.

CASE VI.—Dargau (*Medical and Surgical Reporter*, Aug. 22, 1874) saw a case in which the pancreas protruded through a wound five inches in length, between the last two false ribs, on the left side. The patient was a negro, who had been injured fourteen hours before he came under treatment. The pancreas was replaced, the wound closed, and the patient made a good recovery.

CASE VII.—Caldwell (*Transylvania Journal of Medicine*, 1828, vol. i. p. 116) reports the following remarkable case. In 1816, a negro was stabbed in the left side, and “an oblong body, between three and four inches in length, was observed to have protruded.” Drs. Roberts, Heard, and Caldwell supposed the protruded part might be mesentery, omentum, or lung substance; but, on a more minute examination, that opinion was changed to the belief that it was the small extremity of the pancreas. The protruding part was in a gangrenous condition, and was removed with the knife. The patient soon recovered. The gentlemen who treated the case, “thinking it almost impossible that the pancreas could escape through a part of the diaphragm and between the ribs,” made a critical examination of the part removed, which resulted in their *thorough conviction* that the tissue removed was a portion of the pancreas.

CASE VIII.—Kleberg, who, together with Dr. Wagner, Jr., examined the specimen of pancreas microscopically at the time, reports in Langenbeck's *Archiv für Chirurgie*, vol. ix. p. 523, the following case:

A. S., æt. sixty, a discharged soldier, of powerful frame, and a drinker, was surprised while burglarizing and cut in the abdomen with a knife from below upward while stooping over. He was carried into the surgical wards of the hospital at 6 A. M., having a cut in the abdomen running horizontally about twelve inches in length, between the navel and lower border of the ribs on the right side. Protruding from the wound was a brown-red body about three inches long by two inches in width, of a doughy consistence and covered by a smooth membrane. Immediately after entering the hospital he had a normal passage through the bowels; pulse 72; no pain. The stomach, intestines, and liver



could be excluded on examining the appearance and physical properties of the projecting body. There was no fat, as would have been the case had it been the omentum of such a corpulent person. The prolapsed body was compact and homogeneous, could not be separated into layers, and presented no dilated vessels. It was, therefore, taken to be the head of the pancreas.

Treatment: As reposition of the protruding part did not appear advisable, on account of a possible constriction, and as the consequences could not be foreseen, the part was fixed in the wound with two Karlsbad needles, which were passed through the sides of the wound and the protruding part; a silk ligature was then passed around the pedicle of the protruding part and the end cut off with one stroke of the knife; the profuse oozing of blood was stopped by tightening the ligature. The stump was touched with liq. ferri sesquichlor., and cold applications made over the whole abdomen. There was no fever, peritonitis, or disturbance of digestion in the course of the recovery. The needles and sutures were removed on the fourth day; the stump had become adherent to the edges of the wound. The stump and ligature came away on the tenth day. The patient left the hospital twenty days after admission, with a three-cornered depressed scar. As he was perfectly well nourished during the entire time, it is probable that the caudal extremity of the gland was removed and that the portion of the gland remaining, with the excretory duct, performed the functions of the gland adequately.

The following two cases are from the *Medical and Surgical History of the War of the Rebellion*, Part II. Vol. II., Surgical History, p. 158.

CASE IX. — Assistant Surgeon J. G. Thompson, 77th New York, reports the case of "a soldier, name unknown, who was wounded at Cedar Creek, October 19, 1864. The ball entered the right side, below the ribs, and emerged on the left side. He was removed to the Taylor Hospital, at Winchester. While straining at stool, two days subsequently, a hernia of the pancreas occurred of the size of a hen's egg. A silver wire was passed about the pedicle by which it was attached, and twisted tighter each day for about a week, until it became very small, and was snipped off with scissors. No especial symptoms supervened, and by the last of November the patient was in a fair way

toward recovery, and was moving about the hospital. In December he was still doing well."

CASE X —Private William Freshwater, Co. F., 66th Ohio, received wounds of the abdomen, left forearm, and neck, at Port Republic, June 9, 1862. He was conveyed to Front Royal, arriving on the 13th, and on the 14th was sent by rail to Washington, and admitted, on the 15th, to Judiciary Square Hospital. He was placed in a ward under the charge of Acting Surgeon D. W. Cheever, who states that "a ball had entered one and a half inches outside the left nipple, on a level with the seventh rib, and could be felt under the skin near the spinous process of the left dorsal vertebra. Some viscus, thought to be the lower tip of the lung, protruded at the wound. He died in two days (June 17th) with symptoms of peritonitis. Post-mortem: The ball had pierced the diaphragm without touching the lower lobe of the lung; there was no perforation of the intestines, but they were glued together by peritoneal inflammation. The pancreas protruded at the wound."

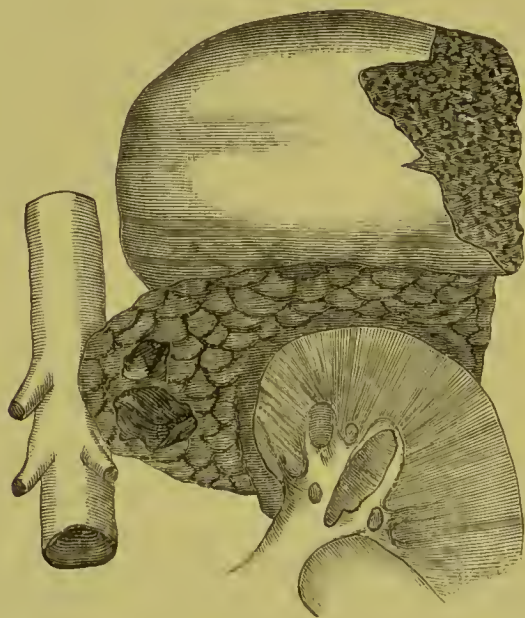
### *Gunshot Wounds.*

The only cases of gunshot wounds of the pancreas that I have been able to find are reported by Otis (*Ibid.*, p. 159).

CASE XI.—Private J. Koprieau, Co. B., 51st New York, aged thirty-two years, was severely wounded at the battle of the Wilderness, May 5, 1864, and was at once taken to the field hospital of the 2d division, Ninth Corps. As the patient could not talk English, the history of the case is quite imperfect. Assistant Surgeon J. C. McKer furnished the following description, which I have abbreviated without omitting essential facts. The patient came under his care May 25, 1864, when it was ascertained that he was suffering from a gunshot wound of the back, the ball entering about six inches to the left of the spinal column, having pushed below the eighth or ninth rib. It was evident that the ball had entered the abdominal cavity, but its course could not be ascertained. Patient's general health was apparently good, and he seemed to suffer but little pain from the injury. Appetite good, bowels regular, urine slightly suppressed and somewhat highly colored. Pulse normally full, but slightly irritable. The patient was ordered quinine, whiskey, nourishing diet, and two doses of acetate of potassa. No noticeable change appeared for about one week, when a severe hemor-

rhage occurred, apparently venous, from the external wound, which was soon arrested by the use of compresses and styptics. About six hours afterward a quantity of urine was voided, which was thickly mixed with blood. These hemorrhages continued to recur two, three, and four times daily till death, the urinal discharge being very frequent, and always bloody. Death resulted June 5, 1864. Post-mortem examination revealed the following: A Minie-ball entered at the middle portion of the eighth rib, fracturing the same, passed through the centre of the spleen toward the pancreas, penetrating this also in a nearly

FIG. 21.



A WET PREPARATION OF PORTIONS OF SPLEEN, PANCREAS, KIDNEY, AND CÆLIAC AXIS, SHOWING MUSKET-BALL EMBEDDED IN THE PANCREAS.

Specimen, Army Medical Museum, No. 2430.

transverse direction, and (probably a few days before death) sinking toward the splenic artery, tearing it, and lodged at its origin from the cœliac axis; the lung was found emphysematous. The ball was found embedded in the pancreas in a pouch between the sloughing artery and vein. The specimen is preserved as a wet preparation in the Army Medical Museum, and is marked No. 2430. (Fig. 21.)

CASE XII.—Corporal A. B. Jones, Co. D., 5th Vermont, aged twenty-seven years, was wounded at the battle of the Wilderness, May 10,

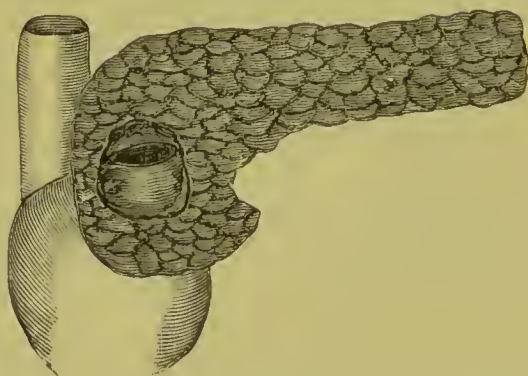
1864, and laid on the battlefield one day and night; was then removed to the field hospital, from there carried by boat to Washington and jolted over a rough road of two miles to the Lincoln Hospital, which he reached about two o'clock in the morning of the 25th. Was seen a few hours afterward by Acting Assistant Surgeon T. L. Leavitt, who found him suffering great agony. On examination it was found that the ball had entered one line to the left and below the ensiform cartilage, passing through the abdominal cavity and making its appearance under the skin just above the crest of the ilium posteriorly, where it was excised at the field hospital. Pulse quick and exceedingly feeble, abdomen distended and tympanitic. Opium was administered and the patient took liquid food freely. About noon of the same day the symptoms improved, wound suppurating nicely. About four o'clock was conversing with nurse, apparently in good spirits, without very great pain; in about five minutes afterward was *in articulo mortis*. The autopsy showed the ball to have perforated the inferior curvature of the stomach, and, strange as it may seem, although an orifice was made directly through the walls of the stomach large enough readily to admit two fingers, no inflammation or even congestion could be detected, except in the immediate locality of the wound, which was beginning to suppurate. Evidently the stomach was also uninjured in its functional capacity, as was witnessed by the reception and digestion of food during life. Some branches of the gastric artery were severed, and about an ounce and a half of dark uncoagulated blood was found. The pancreas was perforated at about its middle, but, except in the immediate track of the ball, gave evidence of no departure from its healthy standard; the intestine and colon were pushed aside during the passage of the ball and were uninjured; the omentum was found in a state of partial decomposition and closely adherent to the small intestine. Liver and spleen healthy. General peritonitis had prevailed and was undoubtedly the cause of death. In this case life was sustained for a period of fifteen days, notwithstanding the serious injury of a vital organ and the exposure to the most unfavorable circumstances and depressing influences.

CASE XIII.—Private William P. B., Co. A., 44th Georgia, was wounded near Fort Stevens, in General Early's demonstration on Washington, July 12, 1864, by a cylindrico-conical musket-ball, which entered below the spine of the left scapula, an inch from the shoulder-joint, and penetrated the chest. He remained a prisoner on the field,



and was conveyed to Lincoln Hospital, a few miles distant, being admitted on July 14th. He was examined by Dr. Leavitt, who found that emphysema extended over the entire left chest, that respiration was painful, but not otherwise difficult, and that there was paralysis of motion of the left arm. There was little change in the progress of the case until the 18th, when the pain in the side became severe, and was somewhat relieved by sinapisms. Following day, dulness over posterior left chest, also extreme dulness in the præcordial region and the heart was forced over to the right side. There was dulness too at the base of the right lung, with indistinct respiratory murmur. On the 20th, jaundice was very pronounced. On the 21st, profuse hemorrhage from the nose and mouth occurred, bleeding coming apparently from the lung. Pulse at this time very weak and thready; jaundice extreme. On the 22d there was much pain in the left side, dyspnœa, consciousness perfect, pulse failing; death at noon, July 24, 1864, twelve days after the injury. At the autopsy the wound was traced from the entrance in the scapula through the fractured fifth rib, the track

FIG. 22.



PANCREAS WITH A CONOIDAL MUSKET-BALL EMBEDDED IN ITS HEAD.

Specimen, Army Medical Museum, No. 2884.

passing downward, inward, and backward, through the lower lobe of the left lung, the diaphragm, the left lobe of the liver to the head of the pancreas, where the ball was found lodged in the head of the viscus, at the angle formed by the coeliac axis with the aorta. The lower lobe of the right lung was hepatized; the left lung carnified, collapsed, and compressed by a large accumulation of black fluid blood. The pancreas was rather large—seven inches long; weight, with ball, five ounces. There was nothing abnormal in its appearance,



except the presence of the foreign body. On examining the pancreas microscopically no deviation from the normal structure was found in sections made from the tissue taken from the left end or tail of the viscus and from the middle part. In close contiguity to the ball is a fine network of fibrillated tissue. As hardened in alcohol the specimen offers no indication of vascular engorgement having existed. The specimen is preserved in the Army Medical Museum, and is marked No. 2884. (Fig. 22.)

REMARKS.—Not in a single instance of the thirteen cases of injury of the pancreas, as reported above, did symptoms during life first point to this organ as the seat of lesion. In all cases where the result was fatal, death was not attributable to the visceral lesion of the pancreas, but was always referable to injury of some adjacent organ. With the exception of cases of prolapse of this organ through a penetrating wound of the abdomen, the diagnosis and treatment of injuries of the pancreas will come under the observation of surgeons only in an incidental manner in the treatment of more tangible and graver lesions within the abdominal cavity. Contusion and laceration of the pancreas as independent conditions are not necessarily fatal injuries, and spontaneous recovery may take place, followed by absorption of the crushed portion of the organ, and atrophy of that portion of the gland which has become physiologically detached from the intestinal tract by the injury or its direct consequences. Crushing of the pancreas is usually not attended by hemorrhage, and in laceration of the organ the danger from this source is much less than in cases of incised wounds.

As modern surgery dictates not only the justifiability but the absolute necessity of treating penetrating wounds of the abdomen, where visceral injury is suspected, by abdominal section, the surgery of the future will undoubtedly deal with contusions and lacerations of the pancreas in connection with visceral injury of some of its adjacent organs. If, in exploring for injuries in this region, the pancreas should be found extensively crushed, it would be good surgery to remove the crushed portion after preliminary ligation of the organ on each side of the comminuted portion. Ligation of the pancreas can be safely done with

a single catgut or silk ligature, as the friable texture of the organ will permit of burying the ligature deeply, a circumstance which will guard against slipping of the ligature. In not a single instance where this method of ligation was resorted to in the experiments on animals, was secondary hemorrhage observed from inefficiency of the ligature. If the pancreas is lacerated, each end of the organ should be ligated for the purpose of arresting or preventing hemorrhage, as well as to guard against extravasation of pancreatic juice into the abdominal cavity.

The results obtained by experiments on animals, as detailed before, have demonstrated in a satisfactory manner that normal pancreatic juice when brought in contact with the peritoneum does not produce inflammation, but is promptly removed by absorption. In the experimental work we always had the advantage of dealing with a normal serous surface, the absorption capacity of which had not been impaired by antecedent pathological conditions, as would in all probability be the case in the operative treatment of injuries of the pancreas. At the same time there can be no doubt that the presence of crushed pancreatic tissue and pancreatic juice in the peritoneal cavity, after abdominal section, would greatly enhance the danger of traumatic infection. For this reason, if for no other, the former should be removed and the escape of the latter prevented by ligation of the pancreas on the side, or each side, of the crushed or lacerated portion.

The cases of protrusion of the pancreas seem to establish the fact that a portion of this viscus may be separated by violence from the splenic artery and other important attachments, and may prolapse through an external wound, and under such circumstances can be removed without hazardous consequences. In most cases the prolapse followed some time after the injury from a sudden increase of intra-abdominal pressure, as coughing or straining at stool. Klebs and Hyrtl's objection to the possibility of a hernia of the pancreas, can find a plausible support only by assuming that the relations of the pancreas have not been disturbed. If, by the violence which produced the penetrating wound, the attachments of the organ are severed, or in

case the attachments have been abnormally loose, or the duodenum is supplied with a long mesentery, there is no tenable reason why the pancreas should not occasionally be found protruding through the external wound. Cases are on record where the pancreas constituted one of the contents of a diaphragmatic hernia, and an instance is reported where it formed a part of the intussusceptum in a case of invagination of the bowel (Bandl).

The treatment of prolapse of the pancreas will depend upon the pathological condition of the viscus at the time the patient comes under the care of the surgeon. If the prolapse is recent and the organ presents no indication of inflammatory or other changes, it should be thoroughly disinfected and replaced. It is of the greatest importance not to resort to violence in effecting reduction, as irreparable damage may be inflicted by resorting to more than the gentlest force. When reduction is not readily accomplished, the wound should be enlarged. If the pancreas is in a condition of inflammation or gangrene, the parts should be thoroughly disinfected and the organ pulled further into the wound until healthy tissue is reached, when a ligature is applied and the diseased portion removed with the knife or scissors. After another thorough disinfection the stump is dropped into the abdominal cavity and the external wound closed. Thorough primary removal of infected tissue is the only safety against subsequent extension of the infection to the peritoneal cavity, and the only guarantee for primary union of the abdominal wound.

In gunshot wounds of the pancreas we have no guiding symptoms upon which to base even a probable diagnosis. The point of entrance and exit of the ball, and its probable course, are the only facts which may point to the pancreas as one of the injured organs. In four of the five cases the projectile penetrated posteriorly in the space between the angle of the left scapula and the angles of the ribs, and passed through the diaphragm and the solar plexus; in one, the ball entered anteriorly near the tip of the xiphoid cartilage, and was believed to have passed through the stomach.

It is a notable and somewhat significant fact, that in all cases

where life was prolonged for more than twelve days, the pancreas appeared to have undergone but little or no pathological change in the vicinity of the visceral wound. Although in all cases the track of the ball did not remain aseptic, the inflammatory changes did not materially affect the parenchyma of the gland.

In Case XIII. the formation of a capsule around the bullet had already been initiated, and if the patient had lived there is every reason to believe that the foreign body would have become encysted in the parenchyma of the pancreas. Gunshot injuries of the pancreas, when they come under the observation of the surgeon as an independent lesion, or as a complication of other visceral injuries in cases of penetrating wounds of the abdomen treated by laparotomy, should be treated in the same way as a contusion or laceration of the gland. The results obtained by the experiments have shown that if only a comparatively small portion of the pancreas remains in physiological connection with the duodenum, this portion of the gland retains its normal structure and its physiological function, which, in all of the experimental cases, was found adequate to supply the requisite quantity of pancreatic juice necessary for the maintenance of normal digestion. While the surgeon may unhesitatingly remove the tail and a portion of the body of the pancreas without fear of any immediate or remote ill effects, great care must be exercised in operating in the vicinity of the head of the pancreas to preserve the integrity of the common duct, and as much of this portion of the organ as may appear compatible with the condition which necessitated the operation.

The results of the experiments made with a view to ascertain how much of the mesentery of the duodenum can be detached without causing gangrene of the bowel have been such as to encourage a conservative plan of treatment when operating in close proximity to the intestine. The observations made in this direction have shown that it is comparatively safe to detach a portion of the mesentery even to the extent of one to three inches, a procedure incomparably easier and much safer than enterectomy combined with partial excision of the head of the



pancreas. I wish again to emphasize the fact that complete extirpation of the head of the pancreas with the common duct is never justifiable, and that operations upon this portion of the gland for injury or disease must be limited to partial excision of the head, with preservation of the common duct.

## VI. ACUTE PANCREATITIS.

Acute idiopathic pancreatitis is an exceedingly rare affection ; only a few well-authenticated cases of the disease have been reported. A brief consideration of this affection is necessary in connection with our subject for the purpose of calling attention to a few of the most constant and prominent symptoms which characterize the disease, inasmuch as all suppurative lesions of this organ, which are of special interest to the surgeon, are preceded by inflammation. The disease originates either primarily in the inter-acinous connective tissue of the organ as a pancreatitis, or it occurs as a secondary disease from extension of a peripancreatitis to the substance of the gland. Haller and Klob have given an accurate clinical description of a case observed at the Allgemeine Krankenhaus in Vienna, with a careful account of the post-mortem appearances (Schmidt's *Fahrbücher*, 1860, vol. i. p. 306).

CASE I.—A gilder, sixty-three years of age, had been suffering from indigestion, which was referred to a defective stomach digestion. Flatulency and vomiting were prominent symptoms. The patient was anæmic, and presented a cachectic appearance ; tongue slightly coated, anorexia, epigastrium tympanitic and tender to pressure. Vomiting of a thin, yellow, bitter fluid. Slight elevation of temperature ; pulse 90 ; lower extremities œdematous. The same evening vomiting, collapse, and great pain in epigastrium, extending over the abdomen. During the night obstinate vomiting, traces of blood in the ejected matter ; urine dark colored, contained no albumen. Next day vomiting ceased, but collapse increased, followed by death toward evening. The autopsy revealed serous infiltration of gray matter of brain and lungs. The stomach was collapsed, its mucous membrane bulging. The pos-



terior wall of the stomach was perforated in three places, the openings being as large as a pea, and funnel shaped, with the larger extremity directed toward the peritoneal surface. The edges of these perforations were quite friable, discolored, and continuous with a fetid abscess cavity, which extended from the posterior surface of stomach to the spinal column, and from the spleen to the pylorus, in which the pancreas was found as a grayish, discolored, flabby, thin, and exceedingly fragile mass infiltrated with pus. In front of the anterior wall a fringed portion of the bursa omentalis was found, and on the upper border the arteria and vena lienales were seen; the latter was filled with a thrombus. Examined under the microscope the parenchyma of the gland showed that the cells were degenerated, being distended and turbid; acini separated, at some places collapsed, and the spaces between them contained granules and large globules of fat.

In this case the course of the disease was quite acute, terminating in diffuse suppuration, and death after an illness lasting only sixteen days. The absence of disease in any of the adjacent organs, and the advanced pathological changes in the gland, pointed to the pancreas as the primary starting-point of the inflammation.

CASE II.—Mayo (*Outlines of Human Pathology*, London, 1836, p. 409) also gives an interesting description of a fatal case of subacute pancreatitis, with the post-mortem appearances. The patient was a lady, twenty-one years of age; when five months advanced in pregnancy she lost her usual healthy appearance, and gradually became very anæmic. She complained of great thirst, and also suffered much from pain in the epigastric region, which was sometimes so severe as to oblige her to retire to her apartment. After her delivery the thirst remained, and the weakness and paleness increased. Her state and symptoms were like those of persons who have lost large quantities of blood. About five days before death the stomach became irritable, and nothing but rennet-whey in small quantities was retained. She died five weeks after delivery. Upon inspecting the body the viscera generally were found pale and bloodless. Besides serous effusion on the membranes of the brain and the abdominal organs no pathological changes were observed, except that the pancreas was throughout of a deep and dull red color, which contrasted very remarkably with the

bloodless condition of other parts. It was firm to the touch externally; and when an incision was made into it the divided lobules felt particularly firm and crisp.

CASE III.—Haidlen (*Centralblatt für Gynäkologie*, Sept. 29, 1884) reports the following case from Fehling's private practice. A woman, aged thirty-three years, became pregnant, and during the period of gestation had considerable gastric disturbance and headache. She remained well three weeks after delivery, when there was some hemorrhage. A little later she had two attacks of pain in the region of the stomach, and five and a half weeks after delivery she had a very severe attack of pain in the pyloric region, accompanied by vomiting. There was no elevation of temperature, the pulse was 100 to 104, and regular. The epigastric region was sensitive to pressure, but there were no symptoms of peritonitis, the skin was pale and not jaundiced. The patient seemed somewhat collapsed. In the afternoon of that day she seemed worse, the skin was paler, the pulse more rapid, and the vomiting had ceased. Physical examination showed marked swelling of the abdomen, and great tenderness over pyloric region. No pelvic disturbances. On the following day the patient was better, but the symptoms returned, and she died, in collapse, in ninety-six hours. The autopsy showed that there was no peritonitis, though a small amount of a dirty, bloody-looking fluid was found in the lower part of the peritoneal cavity. The organs, with the exception of the pancreas, were normal. The pancreas had undergone considerable changes: it was larger, thicker, and broader than normal, and in only a few places was its normal color retained; it had changed almost entirely to a brownish-red, blood-suffused mass, containing a small clot of blood on the anterior surface, in contact with the mesentery, but there was no perforation anywhere. The adjacent portion of the mesentery was suffused with blood. Ziegler, who made the microscopic examination, pronounced the case one of acute pancreatitis, and stated that the duct of Wirsung was somewhat dilated, and that he also found small-celled infiltration of the pancreatic tissue.

REMARKS.—The immunity of the pancreas from disease is attributed by Gross to the singular structure of this organ, to its concealed situation, and to the absence of everything like a proper envelope. (*Elements of Pathological Anatomy*, Philadelphia, 1857.)

The first two cases may serve as types of the two distinct forms of inflammation of the connective tissue of the pancreas, the suppurative and interstitial. Another form, the parenchymatous variety, is occasionally met with in the puerperal state, in cases of typhoid fever, pyæmia, yellow fever, and other acute infectious diseases, the post-mortem appearances of which are illustrated by Case III. In this form the pancreas is red, swollen, and œdematous. Microscopically in this variety the most prominent lesion consists in swelling and undue granulation of the glandular epithelium and hyperæmia. (DeLafield and Prudden, *Pathol. Anatomy and Histology*, New York, 1885, p. 369.)

In the first case the symptoms were acute, and the disease terminated in death in the short space of sixteen days. The suppurative inflammation beginning in the interstitial tissue involved the entire gland, and extended by continuity to the para- and peri-pancreatic tissue, giving rise to a diffuse and acute abscess. The termination is sufficient evidence that the inflammation was produced by a specific cause—the pus microbes. In the second case the primary seat of the inflammation was the same, but the process assumed a subacute character, and terminated in a hyperplasia of the connective tissue. The most prominent symptoms in both cases were severe pain in the epigastrium, progressive anæmia, and vomiting. In both cases the pain assumed a neuralgic character. The pain was referred to the region of the cœliac plexus, radiating from there over the abdomen. Neuralgia of the cœliac plexus is one of the most constant symptoms of disease of the pancreas, as Klebs alludes to it as being present eleven times in fifteen uncomplicated cases. Atrophy of the cœliac plexus is mentioned by Klebs as the cause of the neuralgia.

A high degree of anæmia was apparent in both cases from the extensive area of tissue which was found in an œdematous condition, as well as from the statement of Mayo, that his patient presented the appearance of a person who had suffered from repeated and severe hemorrhages. As the pancreas is not concerned directly in the function of hæmatogenesis, we can only explain the constancy with which this symptom is mentioned,

by assuming that the anæmia was due to imperfect digestion and assimilation, caused by an arrest of pancreatic secretion. Vomiting was an early and troublesome symptom in the first case, but appeared only toward the close of the disease in the second case. No reference is made to the condition of the stools in either case. The presence of undigested fat in the stools is, however, one of the rare symptoms of disease of the pancreas. Klebs states that in three cases where this symptom was present, the ductus Wirsungiani was either entirely or partially obliterated, while in a number of cases where the duct was in the same condition the stools remained normal.

#### VII. CHRONIC INTERSTITIAL PANCREATITIS, OR SCLEROSIS OF THE PANCREAS.

This lesion consists in an increase of interstitial connective tissue which may affect the entire organ or remain limited to some particular portion, more especially the head of the gland. During the early stages of the disease the organ is enlarged, more vascular and firm, while later the cicatricial contraction of the interstitial deposit produces atrophy of the parenchyma, with a corresponding diminution in the size of the organ. This form of inflammation of the pancreas is of particular interest to the surgeon, as the cicatricial contraction may produce secondary changes in the pancreatic or bile-ducts, an occurrence which would indicate a resort to surgical measures for the relief of immediate symptoms due to retention of the secretions.

The causes which produce sclerosis are often obscure, but usually referable to some antecedent affection in some of the adjacent organs of the pancreas, as the peritoneum, subperitoneal tissue, duodenum, the common bile-duct, or pancreatic lithiasis, where the primary cause is in the pancreas itself. The connective tissue proliferation destroys the parenchyma by compression and constitutes one of the causes of stenosis of the pancreatic duct.



CASE I.—Todd (*Dublin Hospital Reports*, vol. i.) observed this condition in a girl fourteen years of age, in whom the head of the pancreas and the neighboring connective tissue were the seat of the disease. This case is of unusual interest, as the contraction of the cicatricial tissue produced obstruction of the common bile-duct by compression, which caused a dilatation of the bile-ducts behind the seat of obstruction, converting them into a large sac, which was located behind the duodenum and reached downward as far as the sacrum and laterally from one kidney to the other.

CASE II.—O. Wyss (Virchow and Hirsch's *Jahresbericht*) gives a description of another case in point. A man, fifty years of age, became deeply jaundiced and had three or four loose, clay-colored stools daily. He died after an illness of four and a half months' duration. At the autopsy the liver was found enlarged and of a deep olive-green color. Gall-bladder and bile-ducts were much dilated and contained inspissated bile. The common bile-duct entered the head of the pancreas four centimetres before its termination in the duodenum and traversed the indurated portion of the organ for a distance of two and a half centimetres. At this point the duct was found so much contracted that only a fine probe could be passed through it. The common pancreatic duct was dilated, also its branches, which at some points were dilated in the form of cysts, varying in size from that of a hempseed to that of a hazelnut. Wyss attributed dilatation of the common duct to compression by one of the smaller cysts in the head of the pancreas, but it is more than probable that the dilatation was due to the cirrhotic contraction of the organ.

That icterus is not a constant symptom of this condition is illustrated by the following case, reported by Claessen:

CASE III.—A man, thirty years of age, had been subject to indigestion, constipation, and severe pain in the epigastrium for several years. After his death it was shown at the autopsy that the head of the pancreas and the acini were yellow, and the inter-acinous connective tissue abundant, and yet the duct of Wirsung and the bile-duct were not contracted.

REMARKS.—The surgical treatment of sclerosis of the pancreas can only apply to secondary lesions which result from stenosis



of the pancreatic or bile-ducts and distention of these passages by accumulation of the secretions. Such an occurrence is most apt to take place when the disease affects the head of the pancreas, as the cicatricial contraction in this locality may cause stenosis of either the duct of Wirsung, the common bile-duct, or both. Any operative interference in these cases will be of necessity limited to an attempt to secure an artificial outlet to the retained secretion. The restoration of the permeability of the natural outlet by any method of treatment is entirely out of question.

The tendency of the disease is to aggravate the obstruction as cicatricial contraction progresses. The history of all these cases pointed to an impairment of digestion as the principal clinical feature in each instance. It is, therefore, of considerable importance to examine carefully into every obstinate and obscure case of indigestion, with a view to eliminate the possibility of organic disease of the pancreas as the cause of the derangement of digestion. In cases of permanent retention of the bile or the pancreatic juice caused by cicatricial compression of the bile-duct or the pancreatic duct, the earlier symptoms will have reference to a history of obstinate indigestion, progressive in its character. If, on the other hand, the obstruction is produced by the impaction of a calculus, the previous history points to attacks of sudden and severe pain and other symptoms indicative of the passage of a calculus along the excretory duct.

In case of biliary retention cysts, as represented in Case I., the establishment of an external biliary fistula would result in a permanent fistula, as the impermeability of the bile-duct would preclude the possibility of reëstablishing, by any kind of an attempt, the normal communication between the dilated bile passages and the intestine. Such an operation would remove only the urgent symptoms due to retention and absorption of bile, but would leave unchanged the primary cause of the retention and would exclude, permanently, the bile as a digestive fluid from the alimentary canal. As the obstruction is permanent and irremediable, the operation which suggests itself as fulfilling the urgent indications, as well as preventing remote ill

consequences, is the formation of a new outlet for the bile into the intestinal canal, by establishing a permanent fistula between the duodenum and the gall-bladder, or between the duodenum and the dilated bile-ducts. Duodeno-cholecystostomy has a future in all cases of permanent and incurable obstructive lesions in the bile-duct, and will become an established operation as soon as it has been perfected by an improved technique.

My experiments on animals have demonstrated that physiological detachment of any portion of the pancreas is invariably followed by degeneration and atrophy, irrespective of the particular method by which this detachment is effected; consequently it is only reasonable to assume that permanent obliteration of the pancreatic duct by cicatricial contraction is always followed by degeneration of the parenchyma of the gland on the distal side of the seat of obstruction.

It is on this account that stenosis of the pancreatic duct is seldom followed by dilatation of the ducts to any considerable extent on the distal side of the constriction, and even more seldom by the formation of a cyst. A retention cyst can result from obstruction only so long as secretion has not been entirely suspended, and when, at the same time, absorption of the pancreatic juice does not take place on account of further extensive pathological changes in the structures which perform this function when the gland is otherwise in a normal condition.

As the physiological detachment by obstruction of the common pancreatic duct caused by cicatricial contraction is invariably followed by complete destruction of the parenchyma of the contributory portion of the gland, it is evident that the surgical treatment of a cyst of the pancreas in such cases can be indicated only when the swelling becomes, in itself, a source of serious inconvenience and pain. The proper treatment in all such cases consists in the formation of an external pancreatic fistula by abdominal section. There is no danger, in such instances, of the fistula remaining permanent, as the glandular tissue which might remain at the time of operation will, in the course of time, disappear by degeneration and absorption. As in animals, so in man, the health of the individual after gradual atrophy of the

pancreas will depend upon the physiological capacity of vicarious organs, in each particular case, to assume the functions of the pancreas.

In recapitulation, it may be stated that cirrhosis or chronic interstitial pancreatitis sometimes produces stenosis of the bile-duct or the pancreatic duct, and that, when the obstruction is followed by retention of the secretions, an operation becomes always necessary in biliary retention, which should be treated by establishing a new outlet for the bile into the duodenum, while the formation of an external pancreatic fistula in cases of cyst of the pancreas becomes necessary only when the presence of the swelling in itself has become a source of sufficient pain and discomfort to warrant treatment by abdominal section.

### VIII. GANGRENE OF THE PANCREAS.

One of the terminations of acute inflammation of the pancreas is gangrene. Cases have been reported where spontaneous recovery followed elimination of the necrosed organ through the alimentary canal. If spontaneous recovery in this condition is possible, it would seem plausible that a timely removal of the necrosed organ by surgical interference would add to the chances of recovery, consequently we shall add gangrene as one of the diseases of the pancreas which should be treated by operative measures.

CASE I.—Trafoyer, of Hernals, treated a patient suffering from what appeared to be a passage of gall-stones. During the course of the disease the patient passed, per rectum, a solid mass, the nature of which could not be readily ascertained. This mass was sent for examination to Rokitsansky, who found in it gall-stones and a large part of the pancreas in which the duct was plainly visible. Rokitsansky believed that a portion of the pancreas had become invaginated into the duodenum and had sloughed. Nothing could be ascertained concerning the subsequent history of the case. (*Allgem. Wiener Zeitung*, No. 29, 1862.)

CASE II.—Reported by Chiari (*Wiener med. Wochenschrift*, Nos. 6 and 7, 1881). Female, aged forty-six years, who had been subject to occasional attacks of pain in the stomach. She was seized suddenly with severe pain in the abdomen, followed by vomiting and other symptoms of diffuse peritonitis. Toward the close of the disease she had a chill, and vomited a black, very offensive fluid. At the necropsy the pancreas was found separated from all its attachments and of a brownish color. The duodenum and transverse mesocolon were perforated, the bursa omentalis contained an offensive sanious fluid, consecutive to diffuse peritonitis. The pancreatico-duodenal artery was eroded.

CASE III.—(*Ibid.*) Patient, a man thirty-eight years of age, was attacked with symptoms indicative of cholelithiasis, followed by symptoms of obstruction of the bowels which lasted for a number of days, and subsided only after the passage, per rectum, of the greater portion of the necrosed pancreas. The patient recovered.

CASE IV.—Israel reports a case of necrosis of the pancreas in a patient suffering from diabetes mellitus. (Virchow's *Archiv*, vol. lxxxiii. p. 181.) The autopsy showed a fluctuating tumor between the stomach and transverse colon which revealed itself as a cyst, with thick walls firmly adherent to the intact head of the pancreas. The cyst contained 300 cubic centimetres of a clay-colored fluid, in which crystals of hæmatoidin were found, and the necrosed body and tail of the pancreas. Israel attributes the cause of the destructive process to an inflammation of the peripancreatic tissue, which had given rise to repeated hemorrhages into and around the pancreas. The disease of the pancreas, he holds, was not the cause, but the effect of the diabetes.

CASE V.—Prince ("Pancreatic Apoplexy, with a Report of Two Cases," *Boston Med. and Surg. Journ.*, July 13 and 20, 1883) reports the following case: A man, twenty-two years of age, during a violent exertion, was taken with severe pain in the abdomen, followed by pain in the epigastric region, vomiting, chills, and a sensation of great oppression and uneasiness. In a few days diarrhœa followed, and during the third week he died. At the autopsy the anterior abdominal wall was found firmly adherent to the omentum and intestines; between the intestinal convolutions a chocolate-colored fluid was found. The greater portion of the pancreas was destroyed and converted into a



black gangrenous mass. The mesentery of the upper portion of the jejunum, which was adherent to the lower margin of the transverse colon, showed in its folds an accumulation of thick greenish pus.

CASE VI.—Reported by Rosenbach (*Centralblatt für Chirurgie*, 1882). A woman, fifty-seven years of age, otherwise in good health, had suffered some time ago from pain in the abdomen and constipation, but was soon relieved. Three weeks before she came under observation of the reporter, the same trouble returned. The bowels had not moved for three days; frequent vomiting of greenish fluid; great weakness. On examination, a fluctuating tumor the size of a child's head was detected in the epigastric region, behind the stomach, which was considerably dilated. The tumor was immovable. As the symptoms pointed to intestinal obstruction of some kind, and failed to be relieved by enemata, it was decided to perform laparotomy, to which the patient readily consented. The abdomen was opened through the median line, but, as the tumor was not rendered sufficiently accessible, a transverse incision was made over the part most prominent. After division of the mesocolon an effort was made to enucleate the tumor, but the inflammatory adhesions were so firm that the attempt had to be abandoned. An effort was then made to push the stomach upward, but this likewise failed. During these manipulations the tumor ruptured and at first clear, then turbid offensive fluid poured out. The fluid was removed without soiling the peritoneal cavity. The sac was then stitched to the margins of the wound. After suturing the remaining portion of the external incision the opening in the sac was enlarged and drained. The patient died of shock six hours after the operation. At the autopsy the necrosed pancreas was found in the sac. The abscess cavity extended behind the stomach and lesser omentum. The intestinal obstruction was caused by pressure of the swelling upon the small intestine.

REMARKS.—The pancreas may constitute one of the component parts of the intussusceptum in cases of invagination of the bowels, as such a case has been reported by Bandl, and the specimen examined by Rokitsky furnishes a similar illustration. The second case reported by Chiari may have been of a similar nature, the invaginated portion having sloughed with the remaining portion of the intussusceptum, leaving the continuity of the



bowel unimpaired by adhesions at the point of separation. If, in this instance, the necrosis was due to inflammation, we can only infer that the parapancreatic abscess ruptured into the bowel, and that the necrosed portion of the pancreas was eliminated in this manner, and that subsequently the opening in the bowel was closed. Constipation was a prominent symptom in a number of these cases, and in Rosenbach's case the symptoms of obstruction were so well marked that it was decided to perform laparotomy for its relief. This last case is also of great interest, as during life the existence of a tumor in the region of the pancreas was diagnosticated.

Modern surgery deals extensively with abdominal section for the relief and cure of peritonitis and intestinal obstruction. In searching for the cause of either of these conditions during laparotomy, the pancreas should not be forgotten, and when it is found that the primary disease is located in or around this organ, radical measures should be adopted whenever such a course appears practicable.

Whenever the sac can be stitched to the external incision this should be done, and the sac opened, disinfected, and drained. Search should be made for the necrosed pancreas, and when found detached it should be removed. As in most of these cases the retroperitoneal tissue is extensively infiltrated, a counter-opening should be made in the lumbar region above the kidney, and through drainage established. If an anterior abdominal fistula cannot be established, the course to be pursued should be the same as in treating a pancreatic abscess under similar conditions.

#### IX. ABSCESS OF THE PANCREAS.

At the present time no one familiar with the recent advances in surgery would question the propriety of treating a suppurating cavity by incision and drainage, wherever it might be located. Some of the most valuable recent contributions to surgical literature describe improved methods in treating deep-seated

abscesses. Asepsis and effective drainage are the two cardinal points upon which we have learned to depend in the treatment of abscesses in important organs or cavities. If we can secure and maintain these two essential conditions, we can attack with immunity and a fair hope of success, any abscess wherever it may be located, and whatever its immediate surroundings may be.

In looking over the literature on abscesses of the abdominal organs, we find that modern surgery has been guided almost exclusively by the teaching of the old master: *Ubi pus—ibi evacuo*. It is somewhat surprising that abscess of the pancreas has never been made the subject of surgical treatment. The two principal reasons for this may be found in the facts that abscess of the pancreas is of rare occurrence, and that the recognition of the lesion, when it does exist, is surrounded by many difficulties. There can be no doubt, however, that in the near future abscess of the pancreas will be treated on the same principles as suppuration in any other locality.

The remote location of the abscess may offer many serious obstacles to diagnosis and a rational course of treatment; but these difficulties will be overcome by improved methods of examination, and more perfect methods of operation. As suppuration is only one of the terminations of inflammation, abscess, like inflammation, may occur primarily in the gland itself, or it may commence in the para- or peri-pancreatic tissue. If the abscess is endo-pancreatic, it may be bounded and circumscribed by the proper investment of the gland; if, on the other hand, it commences primarily outside of the gland, it appears as a diffuse abscess, which extends to the pancreas by contiguity; in other words, we speak of the abscess as a suppurative pancreatitis, or a suppurative peri- or para-pancreatitis.

CASE I.—Frison ("Pancreatite suppurée," *Recueil de mém. de méd. mil.*, Mai, Juin, 1876) reports a case of abscess of the pancreas following suppurative pancreatitis, where the collection of pus did not extend beyond the limits of the gland. An otherwise healthy mulatto, twenty-eight years of age, farmer, was attacked in June, 1873, by icterus with no fever. Appetite diminished. The symptoms were not

of sufficient severity to keep him from his work. In August he complained of pain in the right hypochondriac region, which was soon followed by ascites and œdema of legs and scrotum. He was troubled at this time by an intense thirst and voided large quantities of urine, which, on examination, was found to contain sugar. The liver was enlarged and the patient emaciated rapidly. No fever or diarrhœa. Stools clay colored. Appetite gradually declined, and the patient died in a state of advanced marasmus. At the autopsy the intestines and stomach were found normal. The pancreas was enlarged to three times its normal size and infiltrated with pus; the splenic end was distended by a large abscess. Gall-bladder and bile-ducts greatly distended. Liver olive-green in color and contained three abscesses, but otherwise healthy in structure.

REMARKS.—In this case the symptoms during life pointed to the liver as the seat of the disease. The jaundice was undoubtedly produced by stenosis of the bile-duct, either by a catarrhal inflammation of the duct itself, or compression of the duct by the inflammatory exudation which attended the acute inflammation of the pancreas. The ascites was more likely the result of an inflammation of the peritoneum overlying the pancreas than of an obstruction to the portal circulation. The suppuration in the pancreas was not attended by an increase of temperature. The diabetes was probably due to the disease of the pancreas, and was not a coincident affection, as a number of cases of diabetes have been reported which occurred in the course of some disease of this organ.

CASE II.—Timoteo Riboli (*Schmidt's Jahrbücher*, 1859, 2, p. 177) reports the case of a woman, aged fifty-seven years, who suffered from impairment of digestion, loss of appetite, emaciation, and attacks of vomiting in the forenoon. The tongue was coated. No fever, but night sweats. Bismuth and magnesia improved the symptoms for a time, but soon the disease became aggravated. Hepatitis was diagnosed, inasmuch as the patient became icteric and complained of a deeply seated dull pain in the region of the liver and epigastrium. Among a number of colleagues who saw the case in consultation, Tommasini was the only one who believed that the pancreas was the

seat of the disease. The patient was emaciated to a skeleton and died of inanition. At the autopsy the pancreas was found distended with pus. Gall-bladder was distended with bile. Liver congested. No other pathological conditions were found which might serve to explain the cause of death.

REMARKS.—The course of the disease in this case was again afebrile. The symptoms simulated disease of the liver even more closely than in the preceding case, as no mention is made of the presence of sugar in the urine. The suppuration did not extend into the parapancreatic space.

CASE III.—The following case is described by Dr. James Kilgour (*London Journal*, Nov. 1850). The patient was a man, forty-one years of age, who was treated for several years for what was termed bilious dyspepsia. In March, 1850, when first seen by the reporter, he was considerably emaciated and of a melancholic disposition. A prominent symptom was vomiting, especially in the morning, and about two hours after meals. The matter vomited was a sour, viscid fluid, varying in quantity from an ounce to a quart. Skin dry and of a yellowish hue. No diarrhoea, and the stools contained no bile. Urine of sp. gr. 1.022, normal in quantity, loaded with urates, and contained some fat. Pulse small, 100. No pain in abdomen. On left side, from border of stomach to crest of ilium, abdomen was dull on percussion, on palpation inelastic, nodulated, and of a doughy feel. The area of swelling was not well defined. Neither fluctuation nor pulsation could be felt. During the middle of the month of May, the patient complained of chilly sensations, and the area of dulness increased toward the left. Toward the end of the month the chills disappeared and the abdomen became tender and elastic above. During the latter part of July, the legs became oedematous and the patient was somewhat delirious. Toward the close of the disease he was again attacked by a number of chills and died July 28th. The autopsy revealed the stomach distended with gas, its walls very thin; pylorus indurated and slightly narrowed. Duodenum softened by inflammation, the portion near the pancreas being converted into a pultaceous mass. Liver normal. Spleen enlarged one-third. Pancreas enlarged to the size of a teacup, its left end being attached to the suprarenal capsule on same side. On incising the pancreas a milky fluid escaped. The entire gland was converted into a single sac,



which contained purulent fluid with some cheesy particles and fragments of cellular tissue.

REMARKS.—In this case the symptoms were sufficiently clear which would, at the present time, enable an accurate observer to make a probable diagnosis of abscess of the pancreas. The obstinate vomiting, with the absence of signs of disease of the liver, and the progressive emaciation should have led at least to a suspicion of disease of the pancreas.

The location of the tumor was also suggestive of the primary starting-point of the swelling. The abscess cavity was larger than in the preceding cases, and the presence of pus was also suggested by the chills which were present at the beginning and close of the disease. As the abscess cavity was single, this would have been a proper case for surgical treatment. A somewhat uncommon feature in this case was almost complete absence of pain, a symptom which has been considered by Claessen characteristic of disease of the pancreas. The character of the fluid in the cyst would indicate that it was a mixture of pus and pancreatic juice. As in other secretory organs, the suppurative process may commence in the duct and extend to the interstitial connective tissue by continuity. This is the manner in which the presence of foreign bodies, such as parasites or calculi, in the duct gives rise to abscess of the pancreas. In the following case the inflammation of the duct and the consecutive interstitial suppurative pancreatitis were attributed to the presence of an intestinal worm.

CASE IV.—Reported by Shea (*Lancet*, November 5, 1881). The patient was a woman, aged twenty-nine years, who complained of abdominal pain and was jaundiced. After a few days, she improved under a mild alkaline treatment, but about three weeks subsequently again became worse. The pain was in the region of the pancreas. At the same time she suffered from nausea followed by vomiting; jaundice reappeared. Active treatment was resorted to, but she soon became unconscious and died forty-eight hours subsequently. The necropsy showed that the body was fairly nourished and distinctly jaundiced. The lungs were slightly congested at the base. Liver large, pale, and



soft. Pancreas enlarged and hard, being the seat of an abscess containing pus. A round worm, seven inches long, was found folded upon itself, lying in and obstructing the pancreatic duct, the larger portion of the worm being in the duodenum. The intestines were healthy. In the absence of any other disease, death in this instance must have resulted from inflammation of the duct and parenchyma of the pancreas by the irritation induced by the presence of the worm. The jaundice was undoubtedly produced by the same cause.

Positive evidence is wanting in this case to prove that the suppuration was caused by the presence of the parasite, as the worm might have entered the pancreatic duct after death. We have evidence that in many cases ascarides were found in the ductus pancreaticus, without the presence of abscess or even inflammation. Davaine (*Traité des Entoz.*, p. 115) relates that he has found them present in this locality in four cases, and in none of them had secondary inflammatory changes taken place. Klebs found six worms in one case, four in the head and two in the tail of the pancreas.

CASE V.—Mayo refers to a case that came under the observation of Percival (*Outlines of Human Pathology*, London, 1836, p. 409). The patient was a gentleman who had jaundice and bilious vomiting. A tumor appeared at the epigastrium; his strength failed; blood and fetid pus were discharged by stool, and he died exhausted in three months. At the necropsy the pancreas was found greatly enlarged and contained a considerable abscess; the ductus communis was obliterated by the pressure.

The class of cases which are of special importance and interest to the surgeon are those diffuse abscesses which take their origin in the parapancreatic connective tissue: extensive collections of pus as we observe them in cases of parapancreatitis purulenta. As the glandular tissue is not primarily affected in these cases, early evacuation and drainage of the abscess cavity would not only preserve the anatomical and functional integrity of the gland, but would also serve as a life-saving measure by securing an early outlet of the abscess contents.

The case reported by Haller and Klob, and referred to under the head of pancreatitis, Case I., furnishes a good illustration of cases belonging to this class.

CASE VI.—An interesting case of abscess of the pancreas has recently been reported by Musser (*American Journal of the Medical Sciences*, April, 1886, p. 449). The patient was a male, aged forty-two, shoemaker, who was admitted to the wards of the Presbyterian Hospital, May 12, 1885, and died June 6th following. He was of intemperate habits, but his general health had always been good. His poverty had exposed him to all kinds of hardships. The duration of the present illness was not known, but from his statements it was ascertained that his health had been failing all spring. He had never received any injury. He was considerably emaciated. He vomited only once, and that was on the day of admission. Marked ascites was observed, but nothing else could be found. He remained in a stupid condition, took but little food, and manifested no signs of pain. No fever, no sweating. Palpation showed the liver and spleen to be normal, while an ill-defined tumor could be felt in the epigastric region. Urine contained a trace of albumen, but no casts. The ascites was so great as to warrant tapping, and this was accordingly done. The abdomen was thirty-six inches in circumference at the umbilicus before tapping. Within eighteen hours after tapping, it had filled entirely, and in twenty-four hours measured thirty-two and a half inches. He died of exhaustion.

After death, by palpation a fixed mass was detected in the abdomen, extending from the right mammary line, one inch above the umbilical line, directly across to the corresponding line on the left side. Its upper margin was not well defined, but it appeared to be two inches wide. The abdomen was filled with serum in which some lymph floated. The intestines were matted together by recent lymph. The peritoneum showed signs of inflammation. Corresponding to the position of the mass indicated by palpation, the omentum was found matted together, with its inferior border turned upward, and lying across the stomach. This organ was fixed and dilated, its inferior border extending to the umbilicus. The liver occupied its normal position. The transverse colon extended across the abdomen along the lower margin of the stomach, thus permitting the omentum to occupy the position indicated above. Further study of the relations of the abdominal organs revealed the formation of a large cavity

containing about a quart of pus. This cavity was formed by the posterior wall of the stomach in front, by the pancreas, duodenum, and transverse colon below, and by an extension, or rather distention, of the peritoneum above and behind. Certainly the pus did not fill the retroperitoneal space or extend into it, and was not in close apposition to the diaphragm or brim. It was situated in the duodeno-jejunal fossa. Adhesions prevented communication with the abdominal cavity and the retroperitoneal space. This abscess cavity communicated with an abscess the size of an orange, situated in the head of the pancreas, its point of rupture into the duodeno-jejunal fossa being in the middle and upper part.

The remainder of the pancreas was made up of dense connective tissue, throughout which there were innumerable pus pockets, varying from a pea to a pecan nut in size. The secreting tissue of the organ was not discernible to the naked eye. The ducts were not occluded, but rather dilated, and no calculi were found. The portal vein was filled with a purulent thrombus. The splenic vein was also partially closed by a soft thrombus. The superior and inferior mesenteric veins were completely blocked by laminated thrombi, which were firmly adherent to their walls. On microscopical examination, the pancreas was found to be made up of old and young connective tissue; in the large interstices of the bundles of old tissue, the glandular structure could be readily made out, while the tubules were seen to be in a state of catarrhal inflammation. The intertubular connective tissue was crowded with young cells.

REMARKS.—In this case the conditions were favorable for successful treatment by abdominal section had even a probable diagnosis been made before the extensive and serious complication of thrombo-phlebitis occurred. The symptoms during life simulated cirrhosis of the liver so closely that it was impossible to differentiate between this affection and disease of the pancreas, although an ill-defined tumor could be felt in the epigastric region. In similar cases an exploratory laparotomy should be done for the purpose of making a positive diagnosis, and, when similar favorable conditions are found, it could be followed at once by radical measures with a view of securing evacuation and drainage of the abscess cavity. In this case the abscesses in the viscus were the result of a purulent pancreatitis; the

secondary abscess, of perforation into the duodeno-jejunal fossa followed by suppurative peripancreatitis.

*Pathology of Abscess of the Pancreas.*

Recent investigations have shown the existence of a direct causative relation between the pus microbes and suppuration, hence we must take it for granted that every purulent pancreatitis, peripancreatitis, or parapancreatitis is caused by the presence of these germs in the tissues. In case there is no direct invasion by a loss of continuity of the hollow viscera in the vicinity of the pancreas, or no direct communication with the external air by a penetrating wound, we must assume that the germs reach the gland through the circulation, and find a favorable soil prepared by some antecedent pathological change. Such conditions may be determined by contusion of the organ, disturbance of the capillary circulation by various causes, or thrombophlebitis. Norman Moore reports the case of a female, twenty-seven years of age, who had died of pyophlebitis, and where, on post-mortem examination, beside the portal, splenic, and vena azygos minor veins, the pancreatic veins were also blocked by decolorized and adherent thrombi. ("Pathological Observations on the Pancreas," *St. Bartholomew's Hospital Reports*, vol. xviii. p. 207.)

In the *Pathological Society's Transactions* the same author gives an account of two cases of abscess of the pancreas due to plugging of the pancreatic vessels. On page 210 he remarks:

"Pathologically, the case in which thrombosis of the pancreas was found is interesting as indicating how pancreatic abscess is produced. The much commoner condition of the liver in the other cases shows that, had the first patient survived, the thrombosis would certainly have been followed by abscess. Clinically, the value of the case is that it may, in rare cases, help to explain the seat of an obscure abdominal swelling, associated with fever, which has followed a thrombosis, and which physical examination cannot localize in the liver."

Suppuration always begins in the interstitial tissue, either within the gland or in the connective tissue around it. A sup-



purative inflammation and formation of an abscess are different stages of the same process. Peripancreatic suppuration commences, in most instances, in the adjacent lymphatics, the pus surrounding the lymph glands, or forming a small abscess.

In the vicinity of the pancreas these perilymphatic abscesses are not unfrequently met with as one of the pathological conditions of pyæmia. Thus, an abscess in the pancreas with perforation into the peritoneal cavity, was examined by Perle (*De Pancreas ejusque morbis*, Dissert. Berol., 1837). Tulpius saw an abscess of the pancreas as a secondary lesion after an attack of malarial fever. Schmackpfeffer observed the same condition after an operation for strangulated hernia, and Portal after extirpation of a testicle. But suppuration in the pancreas sometimes takes place as an independent affection, without the presence of an appreciable infection-atrism, and in these cases we must assume that the essential and specific noxæ are carried along with the circulating blood, and that localization takes place upon a soil prepared for their reception and growth by previous alteration in texture or circulation. In some instances the process begins upon the outer surface of the gland, the pus separating the gland from its attachments. In the case described by Gendrin the pancreas appeared to have been completely detached, and was lying loose in the abscess cavity.

Many of these parapancreatic abscesses do not present well-defined borders; the pus manifests a tendency to burrow in the vicinity of the mesocolon and the retroperitoneal space, and is apt to perforate into the bursa omentalis, or into some other portion of the peritoneal cavity, or, lastly, finds its way into one of the adjacent hollow organs, as the stomach or intestinal tract. Van Derveren reports the case of a female, fifty-nine years of age, who had suffered for thirty years from attacks of gastralgia. At the necropsy, it was ascertained that the indurated pancreas had perforated the posterior wall of the stomach. The opening represented a round ulcer, two and a half inches in diameter, with indurated margins. In this aperture eroded vessels could be seen. The fistulous tract communicated with the pancreatic duct. The stomach and intestines contained



blood, but no other evidences of disease could be found. In Percival's case the abscess ruptured into the bowel, the stools containing fetid pus and blood. A similar case was observed by Haggarth (*Transactions of the College of Physicians in Ireland*, vol. ii.). The suppurative process, however, may extend in an opposite direction, from the stomach to the pancreas (Rokitansky, *Lehrbuch der pathol. Anatomie*, Wien, vol. iii. p. 168). A communication between the stomach and pancreas is sometimes established by perforation of a gastric ulcer in this direction. Around the margins of the ulcer, between the stomach and pancreas, adhesions are formed, an occurrence which prevents extravasation of the contents of the stomach into the peritoneal cavity. A number of the terminal openings of the ductilis pancreaticis have been observed upon the cicatrized surface of a gastric ulcer. In place of the formation of a permanent pancreatico-gastric fistula as described by Rokitansky, perforation of the stomach in closer proximity to the pancreas may give rise to diffuse and rapidly fatal parapancreatitis or peripancreatitis.

The indirect primary cause of a pancreatic abscess may be due to the presence of a calculus in the pancreatic duct. Fournier has recorded a case where, on post-mortem examination, an enormous abscess was found in the head of the pancreas, which contained numerous calculi. The tumor was sufficiently large to be readily detected in the epigastric region during life.

An abscess of the pancreas may also originate in a pre-existing cyst of the organ. Kilgour's case, detailed above, had undoubtedly such an origin. The abscess cavity was as large as a teacup, and contained a milky fluid and caseous particles, which were undoubtedly a mixture of pus and pancreatic juice. The disease was attended by chills and fever, which indicated that the retention cyst had become the seat of an acute suppurative inflammation.

As primary, idiopathic, uncomplicated, purulent inflammation of the pancreas is an exceedingly rare affection, it is of great practical importance in the surgical treatment of such cases to

determine, if possible, the predisposing cause or causes, and to remove them, or render them inert at the time of operation.

### *Symptoms and Diagnosis.*

The presence of pus within the pancreas or in its immediate vicinity is not indicated by any characteristic or positive symptoms. The symptoms always point to the stomach or liver as the seat of the disease. The most prominent and constant symptoms which have been observed are nausea, vomiting of a clear greenish or viscid fluid, thirst, loss of appetite, constipation, progressive emaciation, and distention of the epigastrium.

In most all cases the patients presented a sallow, cachectic appearance, and were exceedingly anæmic. Ascites and œdema of the lower extremities were present a number of times. In several instances the inflammatory process in the pancreas extended to the bile-duct, or caused stenosis of the duct by compression, conditions which are followed by biliary retention, a symptom which has been usually interpreted as an evidence of primary disease of the liver or bile-ducts. The progressive anæmia and emaciation, in the absence of other tangible lesions, are symptoms which always should direct attention to the pancreas as the seat of the disease.

Fever was seldom a conspicuous and never a constant symptom of suppurative pancreatitis. The use of the thermometer in the diagnosis of suppuration in this locality is important, but it furnishes no positive evidence. If the abscess is large, it will be recognized by palpation and deep percussion as a tumor in the epigastric region. In such cases a probable diagnosis may be made by a careful and systematic physical examination and reasoning by exclusion.

An abscess within the gland is always located in the bursa omentalis; a peripancreatic abscess in the bursa omentalis, duodeno-jejunal fossa, or upper portion of the peritoneal cavity; and a parapancreatic abscess in the retroperitoneal space. Inflation of the stomach will often serve a useful purpose in the differential diagnosis of tumors in the epigastric region. In

obscure cases, manual exploration of the rectum may add important and sometimes decisive information.

Age is also an important element to be considered in the diagnosis. Most of the cases of abscess of the pancreas were patients of more than forty years of age, and often persons of intemperate habits. Puncture with an aseptic capillary needle will demonstrate the presence or absence of pus, but will not add material information in locating with accuracy the abscess cavity.

Finally, in all cases where a tumor can be felt in the epigastric region, and a probable diagnosis can be made regarding its benign character, an exploratory laparotomy should be resorted to for the purpose of making an accurate anatomical diagnosis.

### *Prognosis.*

The prognosis of abscess of the pancreas is always unfavorable. Death is produced by progressive emaciation and inanition, by septic absorption, or secondary lesions in adjacent organs. In acute, diffuse pancreatic abscess a fatal termination may take place in a few days. One of the great dangers of abscess in this locality is the close proximity of numerous important veins, which become implicated by extension of the suppurative inflammation to their walls, producing a suppurative thrombophlebitis, with all its disastrous consequences. Perforation of the abscess into the stomach or intestinal tract is the most favorable spontaneous termination, and has resulted, at least in one instance, in a cure. Perforation of the abscess into the peritoneal cavity would hasten death by inducing a rapidly fatal septic peritonitis.

### *Treatment.*

The remarkable success which has attended the treatment of pelvic and abdominal abscesses by laparotomy justifies the hope that, in the near future, the same treatment will be extended to abscess of the pancreas. It is true that the difficulties which

surround the treatment of abscesses in this region are many, but they are not insurmountable. Multiple abscesses, disseminated throughout the entire organ, and especially its head, are not amenable to successful surgical treatment. Circumscribed endopancreatic abscess in the peripheral portion of the body or tail of the pancreas should be treated by partial excision of the pancreas in all cases where the isolation of that portion of the organ can be accomplished without inflicting serious injury to adjacent important organs. When extirpation is impossible, as when the abscess is located in the head of the pancreas, it must be treated by incision and drainage. This is accomplished in the same manner as in the treatment of a pancreatic cyst. In some instances, the access to the abscess is rendered difficult by distention of the stomach, the dilated organ overlapping the pancreas. In such cases, the stomach must be pushed upward, and subsequent distention guarded against by ordering an absolute diet until the external fistula has been established. The external incision must, in all cases, correspond to the most prominent part of the swelling, as it is of the greatest importance to incise the abscess at a point where the distance between the surface of the abscess and the abdominal wall is the shortest. Incision of the great omentum will be required in all instances.

In making an external fistula in the treatment of a pancreatic abscess it is essential to protect the muscular and connective tissues of the external incision against contact with pus by lining the margins of the wound with the parietal peritoneum before the serous covering of the anterior wall of the abscess is stitched to the margins of the wound. One of the greatest difficulties that will be encountered in this operation will be the approximation of the peritoneal surface of the abscess with the margins of the wound, on account of the distance between the surface of the abscess and the anterior abdominal wall; this difficulty will decrease in proportion to the prominence of the swelling.

The size of the external incision will exert an important influence in this direction. If the incision is large the margins of the wound can be turned inward, thus facilitating the suturing

of the anterior wall of the abscess to the margins of the wound. As a rule, it may be relied upon that the anterior wall of the abscess, covered by peritoneum, is quite thick, so that there is little danger of penetrating the abscess cavity with the needle in suturing. Previous evacuation of the abscess cavity by aspiration would diminish the danger of extravasation of pus through the needle punctures, but would also render approximation difficult by the recession of the abscess wall, and should, therefore, not be resorted to unless the swelling is sufficiently prominent to render this circumstance of little importance.

As the suturing of the two peritoneal surfaces is done for the purpose of preventing, in the first place, extravasation of pus into the peritoneal cavity; and, secondly, of securing permanent adhesions between the abscess wall and the margins of the wound, it is important to apply the sutures closely together and to grasp the tissues in such a manner that tearing through of the sutures is impossible. As considerable tension may follow, it would be advisable, in this particular instance, to use silk sutures. As in these cases time is an important element, incision and drainage should follow suturing immediately.

The remaining steps of the operation will depend upon circumstances. If the abscess is endopancreatic or peripancreatic, simple incision, drainage, and disinfection will answer all indications. If, however, the purulent cavity is located behind the peritoneum and occupies the connective tissue space behind the pancreas, it would appear rational to drain the abscess posteriorly through one of the lumbar regions above the kidney by pushing a long closed forceps in a proper direction through the posterior and lateral wall of the abscess until its point can be felt under the skin externally. A small cut in the skin over its point will enable the operator to push the instrument clear through, and, by dilating its blades, widen the canal sufficiently to permit the insertion of a large drainage tube. In this manner the most desirable method of drainage—through drainage—could be established, which would render subsequent disinfection and evacuation of the abscess a comparatively easy task. In



cases where an anterior pancreatic fistula cannot be established on account of the distance between the abscess and the anterior abdominal wall, we might resort to lumbar drainage and closure of the incision in the anterior wall of the abscess by carefully inverting and approximating the peritoneum over the wound with fine silk sutures.

That the utmost care in the application of antiseptic precautions should be resorted to in the evacuation of pus in this remote region by any of these procedures requires no argument. I will repeat that a positive diagnosis of the presence and precise location of a pancreatic abscess is only possible by resorting to explorative laparotomy, and that this diagnostical aid should be always resorted to when the history of the case and the symptoms and signs presented are sufficiently suggestive to point to a probable diagnosis.

The abscess found and located by abdominal section should be removed by partial extirpation of the pancreas when it is endopancreatic and located near the splenic end of the pancreas. When extirpation is impossible, or when it is located in the head or on the anterior surface of the pancreas, it should be treated by the formation of an anterior abdominal fistula; when located behind the pancreas, by through drainage, or lumbar drainage performed through the abdominal cavity.

#### X. HEMORRHAGE OF THE PANCREAS.

A number of post-mortem examinations have shown that certain cases of sudden death were caused by hemorrhage of the pancreas, inasmuch as no other evidences were found which could explain the cause of death. In some as yet unaccountable way, even a moderate hemorrhage in this locality has been sufficient to destroy life. Zenker has affirmed that in these cases pressure upon the solar plexus and semilunar ganglion produces paralysis of the heart, to which he attributes the immediate cause of death. If we recollect that tumors of the pancreas, even when of considerable size, do not destroy life in this man-

ner, it seems that the true explanation of the great danger which attends hemorrhage of the pancreas remains to be ascertained. Practically it is important to differentiate between diffuse hemorrhage into the substance of the organ and its adjacent tissue, and circumscribed accumulations of blood or hemorrhagic cysts of the pancreas, as the latter condition presents more favorable indications for surgical treatment.

### *Hemorrhagic Cysts.*

CASE I.—Anger (*Bulletin de la société anatomique de Paris*, xl., Année 1865, 2me série, tome x. p. 192) reports a case of hemorrhagic cyst of the pancreas in a man, aged seventy-two years, who had been a soldier for ten years, during which time he had received several wounds. Later he suffered fracture of several ribs on the left side from a severe contusion, from which injury, however, he recovered completely after three months' treatment in the hospital. No history of syphilis. Five months ago lower limbs became œdematous, and for the last six weeks ascites was present. He was admitted into the Beaujon Hospital February 27, 1865. At this time the following conditions were noted: Ædema of lower extremities; ascites; breathing difficult and stertorous; bronchitis on left side of chest, and hydrothorax on opposite side. Diaphragm pushed upward. Pulse 100, irregular and intermittent. Diarrhœa and loss of appetite. No delirium. Urine contained no albumen. A stimulating treatment was adopted. March 1st the patient died, the pulse having been for a time exceedingly feeble and intermittent. The breathing toward the last was very labored and the patient was unable to lie down.

*Autopsy.* Pleuritic effusion on left side, bronchitis. Liver small, somewhat contracted, but not cirrhotic. Serous effusion in pericardium; heart dilated, mitral valve insufficient. On opening the abdomen a tumor, the size of a fetal head, was found in front of and on the same niveau with the left kidney. This tumor was bounded in front by the stomach and the transverse colon, above by the diaphragm, below by the descending colon, behind by the kidney, toward the median line by the pancreas, and on the outside and above by the spleen. It was loosely connected with the kidney and spleen by connective tissue, in which the vessels of these organs could be readily seen. The tumor was evidently connected with the pancreas.

The external surface was irregular and nodulated, the anterior wall of variable thickness. Fluctuation plain. The vessels of the spleen were intimately connected with the posterior surface and were not easily isolated. On careful dissection the lobules of the pancreas could be separated from the tumor, but the walls of the cyst contained a tissue which resembled glandular structure. On opening the cyst a considerable quantity of dark fluid blood escaped, which contained a number of small, recent coagula. The inner surface of the cyst was uneven and reticulated, resembling in appearance the interior of the right ventricle. On the surface of the prominences, diverticula could be seen, which were in free communication with the principal cyst. The wall of the cyst was very much indurated and thickened at four or five places. Some of these nodules were fibro-cartilaginous in structure, while others had undergone calcification.

Sections of the cyst wall showed under the microscope nucleated epithelial cells which resembled in structure the epithelial cells in the pancreas. Acinous groups of glandular tissue were also found. The reticulated structure in the interior of the cyst contained vessels and remnants of the acini. The author came to the final conclusion that the tumor was a cyst, located in the tail of the pancreas. The presence of blood in the cyst was explained by the supposition that, during the progressive dilatation of the cyst, some of the vessels in the connective tissue reticulum had ruptured.

M. Le Dentu, who examined the cyst, also came to the conclusion that the bleeding had taken place into a preëxisting cyst. What symptoms the presence of the tumor had produced during life could not be ascertained, as the patient was being treated for organic disease of the heart and the tumor was not recognized during life.

CASE II.—Störck (*Archiv gén. de Paris*, Mai et Juillet, 1836) observed the following case. The patient was attacked during the menstrual period by vomiting, which was followed by coldness of the extremities, palpitation of the heart, and dyspnœa. Soon after this time a pulsating tumor was detected in the epigastric region, which caused considerable pain. The patient also suffered from constipation and attacks of vomiting. She died three and one-half months after the first attack. At the autopsy the entire pancreas was found enormously dilated, and weighed with its contents thirteen and one-half pounds. On cutting into it, it was found filled with coagulated

blood. Judging from the condition of the coagula, bleeding had occurred at intervals. The weight of the tumor had caused injurious pressure upon adjacent organs. Le Dentu believed that the hemorrhage was caused by the act of vomiting and had taken place into a preëxisting cyst of the pancreas.

CASE III.—John Parsons (*British Medical Journal*, 1857) reports a case where hemorrhage into a preëxisting cyst proved fatal after the latter had ruptured into the intestinal tract. The patient was a female, sixty years of age, who had suffered from vague dyspeptic symptoms for an indefinite length of time. When she was examined by the reporter a fluctuating tumor the size of an orange could be felt in the epigastrium, just below the greater curvature of the stomach. Emaciation progressed rapidly. The tumor disappeared suddenly, at the same time a viscid, dirty white fluid was discharged through the bowels. The tumor reappeared in a short time, and ruptured a second time into the intestines, followed by hemorrhage into the ruptured cyst which proved fatal. At the autopsy, the pancreas was found excavated into a wide canal which, at either extremity, was dilated into a cyst. The walls of the cysts were of the firmness of cartilage, and the organ was adherent to the stomach, kidney, and colon. Coagulated blood was found in the dilated duct and cysts.

REMARKS.—In Anger's case there is room for speculation concerning the origin of the cyst and the source of hemorrhage. As the cyst had not ruptured and did not remain in communication with the patent pancreatic duct on the proximal side, we can only explain the absence of altered pancreatic juice or at least the absence of cyst contents previous to the occurrence of hemorrhage, by assuming that absorption took place as hemorrhage increased, if we adopt the idea that the bleeding occurred into a cyst which had formed before hemorrhage took place.

Two other explanations might be offered. First, that the parenchymatous hemorrhage produced the cyst, the circumscribed coagulum separating the interstitial tissue, and the lining of this space with endothelial cells developed from the connective tissue cells, and subsequent hemorrhage from the interior



of the cyst wall. Again, the hemorrhagic cyst might have originated in a dilatation of one of the vessels of the pancreas, a varicose ectasia of a vessel.

In the second case it appears more than probable that hemorrhage occurred by rupture of a vessel and extravasation of blood into the altered parenchyma of the gland, distending the entire capsule of the organ—in other words, a hæmatoma of the pancreas. In Parson's case the clinical history and the post-mortem appearances prove beyond all doubt that the fatal hemorrhage took place into a preëxisting pancreatic cyst. The immediate cause of hemorrhage in this case was undoubtedly due to inflammatory changes in the interior of the cyst after the first rupture, and to sudden diminution of intracystic pressure by the second rupture.

### *Diffuse Hemorrhage.*

CASE I.—Reported by H. Hudson Rugg (*Lancet*, May, 1850). A man, aged forty-two years, had just recovered from an attack of acute articular rheumatism, when he was attacked suddenly with a severe pain in the left lumbar region. He became collapsed almost instantly. This was followed by cold, clammy sweat and other symptoms of acute anæmia. He never rallied, and died within a few hours. On opening the abdomen after death a large quantity of recently extravasated blood was found between the pancreas and left kidney. A careful search for the source of hemorrhage was made, when it was found that the blood had escaped through an opening of considerable size, which presented the appearance of an ulcer on the anterior surface of the pancreas, which contained a blood-clot the size of a walnut. Sections through the pancreas showed a number of small excavations filled with blood, the size of a hazelnut and smaller, which looked like aneurismal dilatations.

CASE II.—Reported by Oppolzer (*Medizinische Neuigkeiten*, April, 1859). The patient suffered from severe pain in the epigastric region, followed by vomiting, which always aggravated the suffering. The vomited matter consisted of mucus and bile. The disease was attended by fever, very frequent pulse, cold extremities. The bowels were constipated. No blood was vomited, and the case was diagnosticated as



perforating ulcer of the posterior wall of the stomach. On the third day after admission to the hospital he died. At the autopsy the stomach was found in a healthy condition, but around the pancreas and between the layers of the mesentery a copious effusion of blood was found. The pancreas was the source of hemorrhage. This organ was enlarged to double its normal size, of dark red color, and on section was found infiltrated with a blood-stained exudation between the acini.

CASE III.—Reported by Hilty (*Correspondenzblatt für Schweizer-ärzte*, Nov. 15, 1877). The patient was a mechanic, aged thirty; tall, stout, and muscular, but of intemperate habits. One evening he drank beer to excess, and on the following morning without any premonitory symptoms he was seized suddenly with a painful tension of the abdomen, which gradually increased in intensity. He was sent to the hospital, where on examination, he was found in a collapsed condition. Extremities cold, forehead covered with a cold, clammy perspiration. All the symptoms indicated acute anæmia. On physical examination nothing abnormal was found, except that the upper part of the abdomen was distended and painful, especially to pressure. Diagnosis of poisoning or gastritis was made, and treatment adopted in accordance with this view. The patient never rallied, and died in the evening of the following day. At the necropsy the omentum and mesentery were found loaded with fat. No abdominal effusion and no trace of peritonitis. The diaphragm was pushed upward as high as the fourth rib. In the connective tissue around the pancreas a copious effusion of blood was found. The pancreas was double its normal size, firm in structure, and of a dark violet color. On section the lobules were seen to be of a dark color, and the interlobular tissue infiltrated with blood; this infiltration was most copious in the head of the organ. The gland duct was normal, but the vein running along the lower border of the pancreas was distended with blood-clots. No other pathological conditions were found which could explain the sudden death.

CASE IV.—Described by Portal (*Traite de l'apoplexie*, Paris, 1811). This is the first case of this kind on record. A merchant had suffered for two years from colicky pain in the abdomen, nausea, and diarrhœa; emaciation appeared early and continued progressively. Twenty days before his death fever made its appearance. The pancreas presented

a violet color, was softened, and from its whole surface exuded a black offensive fluid. Stomach and duodenum showed evidences of inflammation at some points adjacent to the pancreas.

CASE V.—Reported by Haller and Klob (*Wiener Zeitschrift*, N. F., 11, 37, 1859). Patient was a man, sixty-six years of age, who had died after a short illness. The pancreas was found almost completely detached, its only connection with the adjacent organs being a few strings of connective tissue. It was surrounded by a serous fluid. The stomach was perforated from without, the cells of the pancreas were disintegrated, granular, and changed into detritus, and the splenic vein was filled with a thrombus.

Kollman (*Bayr. ärzt. Intelligenzbl.*, No. 39, 1881) reports two cases of hemorrhage of the pancreas, the first of which came under his own observation, and the second under the care of Gerhard.

CASE VI.—Female, suffering from stenosis of mitral valve and pleuritis on left side. One afternoon, after having partaken of a liberal dinner, she had an attack of diarrhœa, but no vomiting. During the night she had a chill, and an anxious sensation with jactitations. In the morning of the following day she felt greatly improved, but soon after expired suddenly. At the autopsy there was found subperitoneal extravasation of blood at the pyloric end of stomach. Mucous membrane of duodenum along the convex side was infiltrated with blood, but intact. Pancreas hyperæmic, and surrounded with an extravasation of blood, which was most marked in the retroperitoneal connective tissue, extending to the hilus of the spleen. The tail of the pancreas was more hyperæmic than the remaining portion of the gland, and infiltrated with blood.

CASE VII.—The patient was a female, who, from the symptoms presented, was supposed to suffer from bronchial catarrh, emphysema, ascites, and anasarca. She was suddenly seized with collapse, and died in a few hours. At the necropsy the subperitoneal tissue of the duodenal peritoneum was suffused with blood. Considerable hemorrhage into pancreas, and the retroperitoneal space behind pancreas distended with blood.

REMARKS.—A careful perusal of the above cases must satisfy the most casual observer that the hemorrhage was produced by different causes, and constituted simply an expression of different pathological conditions. In the material presented three distinct, primary, pathological conditions will be recognized: 1. Disease of the bloodvessels of the pancreas; 2. Chronic parenchymatous degeneration of the gland; 3. Acute hemorrhagic pancreatitis.

In Rugg's case the patient had just passed through the stages of acute articular rheumatism, and had not suffered from symptoms referable to organic disease of the pancreas, when he died suddenly from internal hemorrhage, which was traced to the pancreas. The pancreas itself showed no other pathological changes, except circumscribed cavities filled with blood, which are referred to as resembling aneurismal sacs.

Case III., reported by Hilty, is an illustration of the second class. Extensive fatty degeneration was found to exist in the tissues generally. Klob found interstitial hemorrhage in the pancreas, in connection with chronic interstitial inflammation of the pancreas, and as a result of prolonged congestion of the portal vein. Zenker reported three cases, which he observed in the course of one year, to the Naturforscher Verein at the Breslau meeting in 1875. In all, the amount of blood extravasated was slight. His observations on hemorrhagic infiltration of the pancreas as a cause of sudden death are of great importance to the medical and legal profession. Death from this cause takes place more frequently than is generally supposed.

The facts observed by Zenker were nearly the same in all cases. A corpulent subject died suddenly, or was found dead. Post-mortem examination revealed, as the only tangible pathological change, hemorrhagic infiltration of the pancreas and neighboring connective tissue, and advanced fatty degeneration of the pancreas.

Further, there was found in two cases bloody effusion in the duodenum, and in two excessive engorgement of the semilunar

ganglion. Zenker believes that paralysis of the heart, whether directly or indirectly caused, must be regarded as the immediate cause of death in these cases. Diffuse infiltration is more common than circumscribed, showing that the same cause exists throughout the entire gland. The bloody effusion is usually not limited to the capsule of the gland, but infiltrates the adjacent spaces, more especially the retroperitoneal connective tissue. The gland is softened, the anterior serous covering disorganized, and the extravasated blood escapes into the bursa omentalis. These conditions are followed rapidly by death, so that even the peritoneum does not show any secondary changes.

In the last class of cases, where the hemorrhage occurs as a symptom of a peculiar and exceedingly malignant form of inflammation of the pancreas, we have reason to believe that the inflammation is due to the presence of a specific form of infection. Klebs believes that in these cases the corroding qualities of the pancreatic secretion may induce the destructive process. Reasoning from analogy, it is, however, probable that the immediate and essential cause is to be found in some form of microbic infection.

The last two cases illustrate that prolonged congestion of the abdominal organs, from obstruction to the return of venous blood, may act as an exciting cause in producing parenchymatous hemorrhage into the pancreas altered by antecedent pathological conditions.

### *Symptoms and Diagnosis of Hemorrhage of the Pancreas.*

The premonitory symptoms which precede the hemorrhage are referable to the particular kind of tissue changes in the pancreas which predispose to rupture of the bloodvessels. In all instances of pathological hemorrhage we have the usual train of symptoms which point to the textural changes in the pancreas as the seat of lesion. Loss of appetite, nausea, vomiting, epigastric pain, constipation, and debility are the most prominent symptoms in cases of degeneration of the pancreas. When the hemorrhage takes place in the course of an infective,



hemorrhagic pancreatitis, we have a complexus of symptoms indicating the presence of an acute inflammation of the organ, usually attended by a rise in temperature. In some cases the hemorrhage produces death so rapidly, that the symptoms which attend this occurrence are of such short duration, that it has been impossible to determine them by actual observation. When the patient dies from loss of blood, the accident is announced by the well-marked symptoms indicative of external hemorrhage: a sharp pain in the region of the pancreas, followed almost immediately by collapse, cold extremities, absence of pulse, cold, clammy perspiration, and a speedy death. If hemorrhage takes place into a preëxisting cyst, the presence of which has been previously determined, the accident may be suspected if pain is suddenly increased, the tumor becomes larger and more tense, and more particularly if the patient's condition indicates a sudden increase of anæmia. Physical examination can be of value only if hemorrhage occurs into a preëxisting cyst of considerable size, or if the effusion of blood is sufficiently copious to give rise to an appreciable swelling in the immediate vicinity of the pancreas.

### *Treatment.*

The propriety of surgical treatment of pathological hemorrhage of the pancreas can only be entertained when the accident takes place in consequence of circumscribed, benign, pathological conditions, which in themselves do not jeopardize the life of the patient, and which admit of measures for arresting hemorrhage by direct treatment. Operative interference should, therefore, be limited to the class of cases described under the head of hemorrhagic cysts of the pancreas. In well-defined cases belonging to this group, it would be justifiable to resort to abdominal section as the only means of arresting fatal hemorrhage, by direct ligation of the bleeding points, or by removing such localized portions of diseased tissue from which the hemorrhage has taken place.

For instance in Case I., partial excision of the pancreas in



which the ectatic vessel had ruptured would have definitely arrested the hemorrhage without interfering with the physiological function of the remaining portion of the gland. When profuse hemorrhage takes place into a preëxisting cyst of the pancreas, further hemorrhage can be effectually arrested by establishing an external pancreatic fistula of large size, plugging the interior of the cyst with iodoform cotton, and applying firm elastic compression of the abdomen with a rubber-webbing bandage over the antiseptic dressing. If this procedure should fail to arrest the hemorrhage, the abdominal incision should be enlarged and an attempt made to extirpate the cyst with or without resection of that portion of the pancreas from which the cyst has grown, according to the size or location of the cyst.

In diffuse hemorrhage of the pancreas due to localized lesion, the same treatment is applicable as advised in the treatment of hemorrhagic cysts of the pancreas.

## XI. CYSTS OF THE PANCREAS.

For a general consideration of this part of our subject I refer to my paper on "The Surgical Treatment of Cysts of the Pancreas," in the *American Journal of the Medical Sciences*, for July, 1885. I refer to this subject again for the purpose of adding new cases and to modify the statement then made concerning the etiology of these cysts. Since then the following additional cases have been reported.

CASE I.—Dixon (*Medical Record*, March 15, 1884) reports an interesting case of cyst of the pancreas, which terminated in death from compression of the bile-duct by the cyst. The patient was a male, forty-two years of age, who during a period of three months had suffered from three attacks of what seemed to be cholelithiasis, before he came under the reporter's care. For the last ten days he became jaundiced. On examination a tumor was found in the region of the gall-bladder, about four inches in diameter, which fluctuated on palpation and ascended and descended synchronously with the respiratory movements, and received the impulse from the underlying aorta. The tumor was punctured and four ounces of a yellowish-red fluid removed,

which solidified on exposure to the air. Two days after the puncture the tumor was considerably larger than before. The patient's strength gradually failed, until he died, thirty-four days after the puncture. At the necropsy it was ascertained that the tumor was a cyst of the pancreas, with thick walls, and light yellow mucous contents. The cyst occupied the head and part of the body of the pancreas and communicated with the ductus pancreaticus. The tail of the pancreas also contained a small cyst. The large cyst compressed the ductus choledochus in such a manner as to render it entirely impermeable. It is evident that in this case a removal of the pressure by operative treatment might have restored the health of the patient by removing the cause of obstruction to the natural outlet for the bile.

CASE II.—Reported by Riedel (*Archiv für klinische Chirurgie*, vol. xxxii. p. 994). A woman, forty-five years of age, noticed nine years ago a small tumor in the upper portion of the abdomen, which increased slowly in size until a year and a half before she was examined by Riedel. After this time growth was very rapid, so that recently a great deal of pain and distress was experienced from the size of the tumor. When she was examined the abdomen was filled completely with a fluctuating tumor, the pelvis and the lateral regions of the abdomen were free. Laparotomy was performed August 27, 1884. The slightly adherent omentum was easily separated, the cyst was tapped, and about ten litres of a brownish fluid escaped. After evacuation of the cyst, the transverse colon could be seen immediately behind the symphysis pubis. The mesocolon had been separated with the omentum. The cyst was separated from the loose attachments with neighboring organs. Troublesome hemorrhage only occurred from the depth of the wound near the vertebral column, where a ligature *en masse* was applied and several vessels tied; the cavity of the wound, the size of two fists, was dusted with iodoform. Death from peritonitis after ninety-six hours. At the necropsy a portion of healthy pancreatic tissue was found ligatured with catgut. The interior surface of the cyst showed, for the most part, a smooth surface without epithelium. At different points it presented prominences which contained glandular tissue.

CASE III.—Reported by Salzer from Billroth's clinic (*Zur Diagnostik der Pancreascyste*, Prag, 1886). Female, thirty-three years of age, not married, suffered from an attack of typhus fever when she was eighteen years old. On admission into the hospital she stated that during

her convalescence she noticed a swelling the size of a goose egg in the middle of the abdomen above the umbilicus which disappeared in a few weeks. Four years later the swelling reappeared in the same place: it was now the size of a fist, but little movable, and rendered the umbilical region prominent. The size of the tumor increased gradually, until four years ago it had attained the size of a foetal head, and had descended below the umbilicus. A sensation of weight in the stomach, vomiting, pain in the abdomen, were the most prominent symptoms during the last fourteen days. Menstruation regular. Before the operation a systematic and careful examination showed no disease in any other organ. Circumference of abdomen below the umbilicus, ninety centimetres. An unusually large vessel was detected in the abdominal wall in the left hypochondrium, which pulsated strongly, and over which, by auscultation, a bruit could be heard. Abdomen prominent, especially in the median line. On palpation the swelling was recognized as a round, smooth, fluctuating tumor, which was in direct contact with the anterior abdominal wall and could be moved slightly from side to side. Percussion dulness over the entire area of the tumor. Both lumbar regions resonant. Spleen and kidney dulness normal. A vaginal and rectal exploration showed that the cervix and uterus were pushed toward the right side, but movable. Behind the uterus a firm tumor could be felt. The diagnosis made at the time was unilocular cyst of the left ovary. Laparotomy was performed June 5, 1885. Median incision exposed the omentum over the cyst, slightly adherent. An opening was made in the omentum, with blunt instruments, through which the cyst wall became visible. The hand introduced through this opening showed the existence of firm adhesions of the cyst wall to neighboring organs. After enlarging the external incision the gastro-colic ligament could be seen stretched over the cyst. The transverse colon lined the lower border of the cyst, and had descended behind the symphysis pubis. When this portion of the intestine was elevated, it was seen that the cyst belonged to the mesocolon. The separation of the cyst presented many difficulties, consequently its size was reduced by tapping, the opening was closed with pressure forceps, and enucleation commenced through a vertical slit in the gastro-colic ligament. Numerous mass ligatures had to be applied to arrest troublesome hemorrhage.

On the left side of the cyst the same enlarged vessel was met with that could be felt externally; it was found so intimately adherent to the cyst wall that it could not be isolated; it was, therefore, ligated

double with the accompanying vein, and divided between the ligatures. To facilitate the deep dissection the incision was enlarged upward, and the cyst opened and emptied with the patient lying upon the side. The hand was introduced into the cyst, when it was found that the attached portion extended in an upward direction. The artery previously ligated had to be tied again higher up. In completing the tedious enucleation no pedicle was found.

From the position it could be ascertained that the base of the cyst was in the vicinity of the pancreas.

After careful arrest of hemorrhage at the bottom of the wound, and the usual toilet of the peritoneum, the external wound was closed completely, no drainage being used. The patient, who had become considerably collapsed, was rallied by the administration of stimulants. In the evening, temperature  $37.6^{\circ}$  C., pulse 72, pain in abdomen, and nausea. Restless during the night. During the next few days pulse became more frequent, jaundice and diarrhœa, great restlessness and collapse, which terminated in death on the sixth day after the operation. At the autopsy extensive purulent peritonitis was found to have been the cause of death. In the transverse mesocolon a hole was found, through which a fist could be passed. Through this opening a cavity, the size of a fist, was entered, the walls of which were infiltrated with blood and pus. In the bottom of this cavity the exposed pancreas was seen, which appeared divided transversely behind the head. Along the margin of the pancreas the splenic artery and vein were found ligated, and a portion of both vessels excised. The middle portion of the pancreas was absent. A portion of the tail of the organ, five centimetres in length, remained. Spleen enlarged to twice its normal size, otherwise normal in structure. Remaining organs healthy. A microscopical examination of the cyst showed that its walls contained pancreatic tissue. Inner surface not lined with epithelial cells.

CASE IV.—Reported by Kramer, operation performed by Hahn (*Centralblatt f. Chirurgie*, No. 2, 1885). Female, sixteen years of age, after an attack of vomiting and pain in the abdomen noticed a gradual distention of the upper portion of the abdominal cavity. The size of the tumor and the area of dulness corresponding were about the same as in my case. The dulness appeared to be continuous with the hepatic dulness. Echinococcus cyst of the liver was diagnosticated. Laparotomy was performed, and the omentum divided between the stomach and the transverse colon. About two litres of an albuminous



fluid were removed by tapping. The cyst was stitched to the margin of the abdominal wound, incised, and drained. The patient recovered with an external pancreatic fistula, which continued to secrete pancreatic juice for four months.

REMARKS.—The experiments made for the purpose of ascertaining the effect of complete and permanent obstruction of the pancreatic duct, as detailed in the first part of the paper, have demonstrated conclusively that obstruction is not the only nor the most important element in the causation of a pancreatic cyst. That the ligated portion of the pancreas continued to secrete pancreatic juice was demonstrated by the experiments on external pancreatic fistulæ, and yet, of the many cases of ligation of the pancreas, in not a single instance was a cyst, or even an attempt at the formation of a cyst, observed. The only physical evidence of obstruction was apparent in a moderate and uniform dilatation of the duct behind the ligature. The most important etiological factor in cases of cysts of the pancreas must be sought in an arrest of absorption of the pancreatic juice, due either to a transformation of the pancreatic juice by the admixture of pathological products into a substance which is incapable of being absorbed, or to a loss of function in this direction of the vessels which perform this task.

The obstruction in the pancreatic duct may cause retention and accumulation of pathological products, but can never be the sole cause of retention of pancreatic juice in an otherwise healthy portion of the pancreas. In the cases where normal pancreatic tissue was found in the cyst walls, it was more than probable that the pathological condition which had caused the obstruction did not effect complete physiological detachment of the peripheral portion of the pancreas; in other words, the obstruction was not complete. In cases where complete physiological detachment has taken place, either by the application of a ligature, or complete obliteration of the duct by pathological conditions, parenchymatous degeneration and atrophy in the detached portion are such constant results, that the exceptions to this rule must indeed be few, if any.



In the diagnosis of pancreatic cysts nothing new has been added. The history of the case, the primary starting-point of the tumor in the epigastric region, its gradual and almost painless growth, are points which should be carefully considered in the differential diagnosis of abdominal cysts. The treatment by extirpation, as only recently practised again by Riedel and Billroth, is not deserving of imitation.

The post-mortem examination in Billroth's case shows only too plainly the difficulties met with in identifying the tissues at such great depth, and of avoiding unnecessary injury to important structures. I wish again to repeat what I had to say on this method of treatment last year. Extirpation of the cyst would guard most effectually against the formation of a permanent pancreatic fistula, but, on account of the deep location of the pancreas, shortness or absence of a pedicle, and the many obstacles thrown in the way of the operator by adjacent organs, the procedure becomes one surrounded by innumerable difficulties and, in the present state of our science, of doubtful propriety. The formation of an external pancreatic fistula in the treatment of cysts of the pancreas has been so uniformly successful that it should be invariably adopted in preference to excision, and the latter operation should only be resorted to in cases where portions of the cyst wall have become the seat of malignant disease, likewise in cases where life is threatened by hemorrhage into a cyst by rupture of vessels lining the interior of the cyst, and which cannot be controlled by simpler and less hazardous measures.

## XII. TUMORS OF THE PANCREAS.

### *Hypertrophy.*

Störck (*Annus Medicus*, 1836; Schmidt's *Fahrbücher*, Supplement Band, 1836, p. 161) mentions a case of intestinal obstruction caused by hypertrophy of the pancreas.

CASE I.—A man, forty-eight years of age, previously in good health, had felt a sensation of weight and distress after meals, for more than six months. The flatulency also caused distress, and was relieved

at times by drinking large quantities of water. Bowels constipated. The symptoms of obstruction developed gradually, but finally became so severe that nothing was retained on the stomach. After obstruction had become complete, the patient became collapsed and died two days later. At the autopsy no signs of inflammation or effusion in the peritoneal cavity could be found. The head of the pancreas, which was enlarged to the size of an orange, had so completely compressed the duodenum that its lumen would only permit the passage of a goose quill. Pyloric portion of the stomach was enormously dilated, so that this pouch resembled a kind of lesser stomach. The pancreas was softer, more succulent, and fleshier than normal, but not at all indurated.

REMARKS.—As no microscopical examination of the tumor was made, we are unable to classify this case, but considerable doubt must remain whether it was a case of tumor or simple hyperplasia of the gland. The age of the patient and the effect of the tumor upon the duodenum make it quite probable that it was not a case of hypertrophy, but carcinoma or sarcoma. The case illustrates the fact that tumors of the pancreas, when they occupy the head of the organ, are liable to produce intestinal obstruction by compression.

### *Sarcoma.*

Of the malignant tumors of the pancreas, carcinoma is of much greater frequency than sarcoma. Only a very few cases of primary sarcoma of the pancreas are on record.

CASE II.—Mayo (*Outlines of Human Pathology*, p. 411) mentions a case of primary sarcoma of the pancreas, with secondary invasion of the stomach, that came under his care. The patient, a man aged thirty-five years, died after an obscure illness which lasted eight months, during which time it was impossible to locate the disease. He dated his illness back to a febrile attack, which left him in a debilitated condition; and from that time he was liable to dyspeptic symptoms, with variable appetite and undefined uneasiness in the epigastric region. A high degree of anæmia was a conspicuous symptom during life. Although the appetite remained good, and digestion did not appear to be very much impaired, emaciation progressed rapidly. On inspec-

tion all the internal parts were found extremely pale, and void of blood; the heart healthy, but nearly empty. The pylorus was thickened and firmer than usual, and had contracted adhesions to the pancreas. The pancreas was considerably enlarged and of nearly cartilaginous hardness, except some spots, which were soft, with the appearance of medullary sarcoma. No other disease could be detected in any other part of the body.

CASE III.—Lépine and Cornil ("Contribution à l'anatom. path. du pancréas," *Gaz. Méd. de Paris*, 1874, p. 624) examined the body of a man, sixty-two years of age, who had been sick for eleven months, and had suffered from obstinate vomiting for seven months. The head of the pancreas was found very much enlarged; the remaining portion of it was normal. The small curvature of the stomach was adherent to the tumor, the pyloric orifice thickened and its lumen narrowed. The adhesions involved also the liver, diaphragm, and lower surface of the lung. White metastatic nodules were found in both kidneys. Under the microscope, sections of the tumor revealed a sarcomatous structure.

REMARKS.—In the two cases related here, we have the principal types of the clinical behavior of sarcomatous tumors. In the first case the disease involved almost the entire organ, having given rise to extensive local destruction without metastasis; in the second case the disease was limited locally to the head of the pancreas, while it had extended early by contiguity to adjacent organs and by metastasis to distant organs.

Friedreich (Ziemssen's *Cyclopædia*, vol. viii. p. 614) claims that at present we are acquainted with only one single reliable case of primary sarcoma of the pancreas. It is described by Paulick, and was found to be of the small-celled variety; it was taken from the body of a young man who had died of pulmonary and intestinal phthisis. It had not given rise to any noticeable symptoms during life.

### *Carcinoma.*

It is claimed by some pathologists that primary cancer of the pancreas is an exceedingly rare affection, and that in the majority

of cases where this organ is the seat of the lesion it occurs as a secondary affection, having reached it by extension from an adjacent organ, especially from the pyloric extremity of the stomach. While this may be true in many cases, quite a number of specimens have been examined where the disease occurred here as a primary affection. Suché ("De Scirrho pancreat. nonnula," Dissert. Berol., 1834) appears to have examined a specimen which affords a good illustration of primary cancer of the body of the pancreas. The middle of the gland was converted into a hard, irregular, nodulated mass the size of a fist, which rested directly upon the aorta, which imparted to it pulsation during life. When cut into, the tumor grated under the knife, and the cut surfaces presented a laminated appearance. The substance of the tumor was traversed by numerous large veins; both extremities of the pancreas were healthy, and no secondary nodules could be found in any portion of the body. A primary cancer of the pancreas is also described by Schupman (*Hufeland's Journal*, 1841), where the tumor had formed adhesions with the spleen, while the liver contained a number of metastatic deposits. The terminal extremity of the pancreatic duct contained a cylindrical calculus with a number of arborescent projections, which corresponded to the contributory ducts. In another case, reported by Récamier (*Rev. Méd.*, 1830), the cancerous tumor, which involved the tail of the pancreas, was connected with the left kidney and compressed the ureter. The right half of the pancreas was healthy, the diseased portion gray, hard, and lardaceous. The pelvis of the left kidney, in consequence of the compression of the ureter, was hydro-nephrotic. The remaining organs were healthy.

Bright, in 1832, reported a number of cases of primary carcinoma of the pancreas, with a special view of illustrating the effect which disease of this organ would have upon the digestion of fat. In three out of eight cases he noticed fatty diarrhœa, and he was inclined to the belief that this symptom, when present, is almost pathognomonic of the existence of disease of the pancreas ("Cases and Observations Connected with Disease of the Pancreas," *Medico-Chirurgical Transactions*, vol. xviii, p. 1).



In all cases the fatty diarrhœa was associated with jaundice. The following post-mortem account (p. 17) leaves no doubt that the disease was primarily limited to the pancreas:

“The cause of the pressure on the bile-ducts was immediately obvious; for, on placing the hand near the pylorus, a hard lump, of the size of a common egg, was easily felt, and was soon discovered to be the head of the pancreas itself, and not the glands surrounding that part, forming a yellow mass like the boiled udder of a cow, almost cartilaginous in hardness. Its texture was uniformly hard and unyielding, and the whole pancreas partook of the same, but in a less degree. The head of the pancreas was firmly and inseparably glued to the duodenum, and the hardness very nearly surrounded the viscus.”

As undoubted instances of primary cancer of the pancreas, we must mention the published cases of Muehry (*Casper's Wochenschr.*, No. 10, 1835), Albers (*Med. Correspbl. rhein. u. westf. Aerzte*, No 8, 1843), Haldauer (*Assoc. Med. Journ.*, May, 1854), Webb (*Phila. Med. Times*, vol. ii., December, 1871), Gross (*Ibid.*, vol. ii., June, 1872), Luithlen (*Mem. a. d. ærztl. Praxis*, 1872, vol. xvii. p. 309), Roberts (*British Med. Journ.*, Sept. 1865), Wagner (*Archiv d. Heilk.*, vol. ii. p. 285), Bowditch (*Boston Med. and Surg. Journ.*, July, 1872), Davidsohn (*Ueber Krebs der Bauchspeicheldrüse*, Dissert. Berlin., 1872), Williams (*Med. Times and Gaz.*, August, 1852), and Frerichs (*Klin. d. Leberkrankheiten*, vol. i. pp. 146 and 153), as referred to by Friedreich (“Diseases of the Pancreas,” *Ziemssen's Cyclopædia*, vol. viii. p. 608).

According to Da Costa (*North Am. Med. Chir. Review*, September, 1858), cancer of the pancreas is more frequent in the male than in the female, and in preference attacks people more than forty years of age. It usually appears as a firm tumor or scirrhus, with a well-developed connective tissue reticulum. Other varieties of carcinoma have been described. Thus, Wagner observed a cylindroma, and Lücke and Klebs have each met with the colloid variety. The primary starting-point is usually in the head of the organ, whence it extends in all directions. By extension within, it successively invades the body and tail



of the organ, until the whole gland is involved, when it forms a nodulated spherical tumor. The extension of the growth in an opposite direction soon reaches the duodenum, where it produces a narrowing or complete stenosis of that portion of the intestinal canal. A case of this kind is related by Høelscher, where the duodenum was constricted to such an extent that it was entirely impermeable, and the patient suffered for several days from symptoms of intestinal obstruction. While cancer of the stomach is liable to extend to the pancreas, the reverse is not frequently observed. When the carcinoma develops primarily in the pancreatic ducts, it belongs to the variety called cylindroma. The lymphatic glands in the vicinity of the pancreas are invariably affected during the later stages of the disease.

### *Symptoms and Diagnosis.*

Stearrhœa is an important but not infallible symptom of cancer of the pancreas. It is attributed to an absence of the pancreatic juice in the intestinal canal, caused either by obstruction in the duct or suspension of the physiological function of the organ by the neoplastic infiltration. Epigastric pain is an early and important symptom, and is the result of compression of the cœliac plexus by the tumor. The pain often assumes a neuralgic character, and is usually not aggravated after taking food. Vomiting is a frequent symptom, and the matter ejected is generally a watery fluid, sometimes stained with bile. Constipation is an almost constant symptom. Progressive emaciation and anæmia attend malignant disease in any locality, but are unusually well marked in cancer of the pancreas. When the disease extends toward the duodenum, jaundice occurs from stenosis of the bile-ducts by compression or direct invasion by the neoplasm. Bruen has called attention to some forty cases of jaundice due to primary carcinoma of the head of the pancreas, lately reported by another observer, from which it is demonstrated that jaundice is an invariable symptom of primary scirrhus of the head of the pancreas, while it is uncommon when the disease is secondary, or affects the body or tail of the organ.

The most reliable evidence is the appearance of a tumor in the epigastrium behind the stomach. The difficulty of examining the pancreas during health by palpation is appreciated when a physical examination is to be relied upon in locating tumors in this locality. The normal pancreas can be felt only under the most favorable conditions through a thin and relaxed abdominal wall, but in determining its relative size this method of examination affords but little reliable information. A cancer of the pancreas, when it can be felt by palpation, appears in the epigastrium as a hard, immovable or only slightly movable tumor, which is evidently deeply seated in the abdominal cavity. Under favorable conditions the connections of such a tumor with the pancreas can sometimes be demonstrated during life, but a positive diagnosis becomes impossible when, as in most of the cases hitherto recorded, it constitutes merely a part of a general tumefaction of the abdomen. As the tumor is in such close proximity to the abdominal aorta the pulsations of this vessel are imparted to the tumor, and a bruit may even be heard over the compressed vessel; but, in contradistinction to aneurism, the pulsation is felt in only one direction, and the bruit disappears when the patient is placed in the knee-elbow position, as the tumor is lifted from the vessel by the force of gravitation.

That the tumor cannot be always felt is evident from the statement made by Da Costa that he recognized it in only 13 out of the 137 cases he reported; and Bigsby, in an analysis of 15 cases, alludes to its being recognized in only 4.

From what has been said, it will be seen how uncertain the symptoms are in the diagnosis of cancer of the pancreas. A satisfactory conclusion can be reached only after a careful consideration of the history of the case combined with a systematic elucidation of all the symptoms presented, and more particularly by resorting to the advantages to be derived from a systematic and careful study by exclusion.

*Treatment.*

A positive diagnosis of malignant disease of the pancreas is only possible after the tumor has attained sufficient size to be recognizable by palpation, consequently too late for a radical extirpation. When the disease has advanced to this stage it has already involved the greater portion of the gland and, as a rule, has invaded important adjacent organs. Another important element in the surgical treatment of cancer of the pancreas consists in the fact that the disease, as a rule, develops primarily in the head of the organ, a location which, in itself, precludes the propriety of an operation. The most favorable conditions for extirpation are presented if the disease is primarily located in the tail of the pancreas, and has not passed beyond the limits of the capsule of the gland. In such a case, excision of the splenic extremity of the pancreas would offer a fair prospect for a permanent result without endangering, as a remote consequence, the process of digestion, as a sufficient amount of secreting structure would remain in connection with the intestine to maintain pancreatic digestion.

Billroth, in two instances, made a partial resection of the pancreas in removing carcinomatous tumors of adjacent organs. In one case he removed a portion of the head of the pancreas with a cancer of the pylorus, and in another case he removed the tail of the pancreas with a sarcomatous spleen. Both patients recovered from the immediate effects of the operation. In the case of partial excision of the head of the pancreas it is to be assumed that the duct was not injured, that the organ continued to secrete, and that the pancreatic juice was discharged into the duodenum through the uninjured duct. In operating upon the head of the pancreas for malignant disease which has extended to it from an adjacent organ, it is essential to preserve the continuity of the duct, so as to prevent physiological detachment of the remaining portion of the gland, an accident which would be followed by degeneration and complete atrophy, consequently suspension of pancreatic digestion.

If an operation is performed for cancer of an adjacent organ, and the disease has extended to the splenic extremity of the gland, the operation should not be completed without removing a sufficient portion of the pancreas to guard against a local recurrence of the disease in this organ. As in cases of partial excision of the pancreas for other lesions, the pancreas should be ligated before it is divided, so as to prevent troublesome hemorrhage, and at the same time guard against extravasation of pancreatic juice into the peritoneal cavity.

### XIII. TUBERCULOSIS OF THE PANCREAS.

Primary tuberculosis of the pancreas is an exceedingly rare affection; indeed, some pathologists, among them Louis and Lebert, doubt its primary origin in this organ. Cruveilhier only mentions tubercular degeneration of the lymphatic glands upon the surface of the pancreas. In diffuse miliary tuberculosis of the abdominal organs Klebs could find no nodules in the substance of the pancreas on microscopical examination. But in such a condition the gland is often found in a state of parenchymatous degeneration which has been incorrectly interpreted as the first stage of tuberculosis by Ancelet.

When the lymphatic glands around the pancreas have undergone cheesy degeneration we sometimes find similar deposits in the pancreas, which, however, may be cheesy lymphatic glands in the substance of the pancreas itself. Hartmann mentions a case where the pancreas had disappeared completely and its place was occupied by a cheesy mass. Although the pancreas is not disposed to tuberculosis, we have reliable information that in a number of cases this gland was the primary seat of the process.

CASE I.—Reported by Aran (*Archiv gén. de Méd.*, 1846). The patient was a woman, twenty-five years of age, who died of a lingering disease. She had been sick for a year, during which time she felt exceedingly weak, had frequent attacks of vomiting, and the skin became deeply bronzed, in some places almost black. The pain,



which was severe at times, was referred to the epigastrium. The necropsy showed a tubercular deposit in the tail of the pancreas the size of a hen's egg, surrounded by a zone of miliary deposits in the substance of the gland. Miliary tubercles were also found in the spleen.

CASE II.—Mayo (*Outlines of Human Pathology*, p. 410) describes a case where we have reason to believe that the process commenced primarily in the pancreas. The patient was an inmate of Middlesex Hospital, and was under the care of Dr. Wilson. He was thirty-eight years of age and had been ill for sixteen weeks, during the last seven weeks he was confined to his bed. The first symptoms were pain in the abdomen extending along the right hypochondrium to the spine. Twenty-eight days before death he became jaundiced, stools white, urine high colored; for some time he could lie on the right side only, and was often obliged to sit upright to draw breath. A large abdominal tumor had been felt immediately above the umbilicus some time before death, and the right arm and side of the neck had become œdematous. Autopsy: serous effusion into the right pleural cavity. The gall-bladder was distended to a great size so as to contain eight ounces of fluid. The distention arose from an enlargement of the pancreas, the head of which formed an irregular sphere four inches in diameter, which had compressed the gall-duct; the rest of the gland was likewise enlarged. In parts it presented its natural texture and color, at other parts it was infiltrated with tubercular matter, which at two or three points had softened and formed thick pus. A few lymphatic glands, the thymus gland, and kidneys, appeared to be secondarily involved.

REMARKS.—Although in both of these cases the symptoms during life pointed to disease of the pancreas, a sufficiently positive diagnosis to warrant a laparotomy could only have been made after a palpable tumor appeared, and after this time the disease had already passed beyond reach by the appearance of miliary deposits in other organs, an occurrence which would preclude the justifiability of any operative interference. Should abdominal section be performed in a case of tubercular peritonitis, and should such a condition in the pancreas be found as in Aran's case, it would be proper to extirpate the terminal end of the pancreas inclusive of the tubercular abscess.

In Wilson's case the tubercular deposit in the pancreas gave



rise to a large abdominal tumor due partly to the distended gall-bladder, and as such a condition might present itself to the surgeon, in these days of diagnostical laparotomy, it might be advisable, and to the advantage of the patient, to establish an external pancreatic fistula instead of closing the wound. Such a course would enable the surgeon to remove the cheesy material, disinfect the abscess cavity, and to treat its interior with iodoform, all of which, done under antiseptic precautions, would tend to modify favorably the local process.

The removal of compression of the bile-duct by the same procedure would also tend to reestablish the interrupted communication between the bile-ducts and the duodenum by removing the cause of the stenosis.

#### XIV. LIPOMATOSIS OF THE PANCREAS.

Lipomatosis, or fatty infiltration of the pancreas, is a pathological condition of this organ which is characterized by a transformation of the interacinous connective tissue into fat in contradistinction to fatty degeneration of the parenchyma cells, which sometimes occurs as an independent affection. In cases of fatty infiltration the shape and size of the pancreas may remain normal, but the secreting structures themselves may have completely disappeared by pressure-atrophy. This disease is of little interest to the surgeon, except that it may serve as a predisposing cause of interstitial hemorrhage, in which connection it has already received mention; it is here again alluded to as a separate affection to demonstrate that gradual atrophy of the pancreas, even to the extent of complete disappearance of the glandular structures, may occur without causing serious impairment of the digestion. Rokitsansky (*Lehrbuch der path. Anat.*, vol. iii. pp. 313 and 369) has found this condition of the pancreas generally as a part and parcel of a general obesity, especially in intemperate persons, together with fatty liver, heart, and omentum. In the three cases of pancreatic apoplexy described by Zenker, the fatty infiltration of the pancreas was only one of the

many evidences of a diffuse malnutrition of the tissues. In some of these cases the patients exhibited no symptoms during life indicating the absence of the pancreatic secretion, and yet on making the post-mortem examinations complete destruction of the glandular structure was found.

Litten (*Charité Annalen*, 1881) has reported three cases of complete atrophy of the pancreas in which, during life, no symptom of pancreatic disease was observed, such as fatty stools, salivation, lipuria, bronzed skin, celiac neuralgia, etc. In two cases the atrophy was due to pressure, and in one instance it was caused by primary cancer of the pancreas.

In other cases the suspension of the pancreatic function by fatty degeneration of the organ produces well-marked symptoms during life, and may even result in death. Such a case is reported by Lépine and Cornil (*Gaz. Méd. de Paris*, p. 624). The patient was a drunkard, fifty-seven years of age. For six months he had been ailing with indigestion, marked loss of weight, diarrhœa alternating with constipation, no fever, no vomiting. For two months his body was covered with an eruption, and his feet became œdematous. At the autopsy the pancreas was found normal in size and shape, but the parenchyma of the gland had entirely disappeared, and its place was occupied by adipose tissue. The pancreatic ducts were filled with a viscid whitish fluid and small concretions. No other cause of death could be found in any of the remaining organs. Clinical observation appears to confirm the results obtained by experiments on animals, that in some instances complete gradual atrophy of the pancreas is compatible with normal digestion, while, in other cases, the suspension of the pancreatic secretion is followed by serious disturbance of digestion, marasmus, and death from inanition.

The only plausible explanation of the different effects of the same cause can be found in the supposition that in some individuals the compensating function of vicarious organs maintains normal digestion, while in others no such compensating action is established.

## XV. LITHIASIS OF PANCREATIC DUCTS.

Concretions of carbonate and phosphate of lime are frequently found in the pancreatic ducts. They are usually multiple, small, whitish, smooth, or of rough and irregular shape. Calculi in this locality have been found which measure more than an inch in diameter. In Shupmann's case, the calculus weighed 200 grains and measured one and a half Paris inches in length, and from five to six Paris lines in diameter; having a crystalline surface, with processes running into smaller ducts. It was found in the left extremity of Wirsung's duct.

Sometimes the concretions of calcium phosphate and carbonate exist in cases of incrustation of the mucous lining of the ducts. According to Collard de Martigny, the calculous concretion is sometimes composed of phosphate of lime alone. The calculi in this locality are usually solid formations, of fine granular structure with somewhat rough surfaces and very often covered with sharp points of projection. In some specimens the stone presents numerous branches which correspond to smaller pancreatic ducts. The irritation incident to the presence of a calculus in the pancreatic duct is followed by consecutive pathological changes in the duct and glandular tissue of the organ itself. The substance of the organ in the immediate vicinity of the stone becomes the seat of interstitial inflammation, followed by atrophy and sclerosis; the cicatricial tissue produced by this change causes contraction, an occurrence which may still further aggravate the obstruction. In some instances this inflammatory process does not remain localized, but extends over the entire gland, as in the cases observed by Engel, Elliotson, and Curnow. In some cases the concretion gives rise to suppuration, as in Portal's case. His patient had died suddenly with symptoms of aneurism of the aorta, and at the autopsy an abscess was found in the head of the pancreas which contained a number of biliary and pancreatic calculi. In Fauconneau-Dufresné's case, as quoted by Ancelet, the left half of the pancreas contained a number of abscesses, one of which had perforated into the

stomach. The pus contained numerous concretions varying in size from that of a pin's head to that of a bean. Salmade observed a case of lithiasis complicated with abscess of the pancreas, where the swelling compressed the underlying aorta to such an extent that death was produced by the rupturing of a vessel from over-distention on the proximal side of the obstruction.

Mr. Moore (*Lancet*, Jan. 12, 1884) presented to the Pathological Society of London the pancreas of a man, aged forty-three years, who died in St. Bartholomew's Hospital of an attack of pleurisy following gouty symptoms. The main duct of the organ was dilated and contained a calculus of irregular shape, around which was a large abscess in the head of the organ. This abscess pressed upon the orifice of the bile-duct sufficiently to produce great distention of the gall-bladder. A number of cases of cysts of the pancreas have been reported in connection with a calculus in the duct on the proximal side of the cyst, and in which the dilatation of the duct was attributed to obstruction due to the presence of the foreign body in the duct. Complete stenosis of the pancreatic duct, due to intrinsic or extrinsic causes, is always followed by parenchymatous degeneration of the glandular tissue on the peripheral side of the seat of obstruction, which necessarily arrests the physiological function in that portion of the organ, hence we are unable to explain the retention of the secretion from this cause unless impaction of the calculus takes place suddenly. Again, assuming this to be the case, we know that healthy pancreatic tissue will remove its own secretion by absorption in case of sudden stenosis or obstruction of the duct. We are, therefore, forced to explain the occurrence of a pancreatic cyst in the course of gradual or sudden obstruction of the ducts by a calculus, cicatricial or malignant stenosis, to parenchymatous changes in the peripheral portion of the gland rather than to the obstruction. This argument, of course, applies only to the so-called retention cyst. Simple, uncomplicated obstruction of the duct may give rise to accumulation of pathological products which under no circumstances are amen-



able to removal by absorption. The former assertion is well illustrated by the specimen referred to above which Norman Moore (*Lancet*, Jan. 12, 1884) exhibited before the Pathological Society of London, which showed great dilatation of the common pancreatic duct throughout its entire length. Near the orifice the duct was obstructed by a small calculus of irregular shape. The whole gland was hard, and to the naked eye showed a condition of advanced connective tissue hyperplasia. The papilla in the duodenum was enlarged and the hardened tissue of the pancreas constricted the bile-duct so as to cause complete obstruction. The liver showed secondary changes due to the stasis of bile. A microscopical examination of the specimen showed it to be a case of genuine cirrhosis of the pancreas, only a small number of acini remaining in healthy condition. In this case the cirrhotic change in the organ was undoubtedly produced in the same manner as by constriction of the duct as practised in the experiments on animals, the first link in the chain of pathological changes being the mechanical obstruction of the duct by the calculus.

### *Symptoms and Diagnosis.*

A positive diagnosis of pancreatic lithiasis during life is impossible. Calculi and concretions have been found at post-mortem examinations of persons who, during life, did not suffer from any symptoms indicating the existence of such conditions. Pain, fatty stools, hæmatemesis, diabetes, are symptoms sometimes associated with this lesion of the pancreas, but when present they point rather to the existence of a consecutive lesion of the substance of the gland produced by the calculus than to the presence of the calculus itself. If the calculus be arrested at the outlet of Wirsung's duct it may, at the same time, obstruct the outlet of the bile by compressing the ductus choledochus and so cause jaundice. But the same effect can also be produced by cirrhosis of the head of the pancreas, with or without the presence of a calculus in the pancreatic duct. Mr. Morris claims that he has seen cases of pancreatic stone colic, but in



such cases it would be impossible to differentiate between the passage of a biliary and a pancreatic calculus along their respective ducts, as a biliary calculus may obstruct the common pancreatic duct and *vice versâ*.

### *Treatment.*

As the diagnosis of a calculus of the pancreas, *intra vitam*, is impossible, the surgical treatment must be limited to the management of some of its consecutive lesions—cysts, abscess, and retention of bile.

The treatment of cystic disease and abscess of the pancreas has been considered under their respective headings, and I will only add that when these conditions have been caused by an impacted calculus, an effort should be made to recognize the primary cause and, if possible, to remove it. As the surgical treatment of retention of bile due to the mechanical obstruction of the biliary passages is now receiving much attention on the part of surgeons, it is well, in this connection, to call attention to impaction of a pancreatic calculus in the duodenal portion of the pancreatic duct as an occasional cause of obstinate jaundice. If, in a case of this kind, abdominal section should reveal the true nature of the obstruction, an effort should be made at the time to force the calculus into the duodenum by taxis, and if this cannot be accomplished, the propriety of cutting for the stone should be carefully considered. As an impacted calculus in this locality not only endangers the life of the patient by cholæmia, but may also destroy life suddenly by perforation into the peritoneal cavity, it would be not only justifiable but good treatment to remove it after a positive diagnosis has been made by means of diagnostical laparotomy. The greatest danger attending such a procedure would be extravasation of bile into the peritoneal cavity. This accident should be guarded against by removing the retained bile by aspirating the dilated bile-ducts as a preliminary measure. After extraction of the stone the incision in the duct should be accurately closed with fine silk sutures. The secretion of bile and pancreatic juice should

be reduced to a minimum after the operation by keeping the digestive organs in a condition of absolute physiological rest during the time required for the healing of the visceral wound.

In conclusion, I beg leave to submit for your further consideration and discussion the following propositions:

1. Restoration of the continuity of the pancreatic duct does not take place after complete section of the pancreas.
2. Complete extirpation of the pancreas is invariably followed by death, produced either by the traumatism or gangrene of the duodenum.
3. Partial excision of the pancreas for injury or disease is a feasible and justifiable surgical procedure.
4. Complete obstruction of the pancreatic duct, uncomplicated by pathological conditions of the parenchyma of the organ, never results in the formation of a cyst.
5. In simple obstruction of the pancreatic duct, the pancreatic juice is removed by absorption.
6. Gradual atrophy of the pancreas from nutritive or degenerative changes of the secreting structure is not incompatible with health.
7. Physiological detachment of any portion of the pancreas is invariably followed by progressive degeneration and atrophy of the glandular tissue.
8. Extravasation of fresh normal pancreatic juice into the peritoneal cavity does not produce peritonitis, but is promptly removed by absorption.
9. Crushed or lacerated pancreatic tissue is removed by absorption, provided the site of operation remains aseptic.
10. Complete division of the pancreas by elastic constriction is never followed by restoration of interrupted anatomical continuities.
11. Limited detachment of the mesentery from the duodenum, as required in operations upon the pancreas, is not followed by gangrène of the bowel.
12. In all operations upon the head of the pancreas, the physiological connection of the peripheral portion of the gland

should be maintained by preserving the integrity of the main pancreatic duct.

13. Partial excision of the splenic portion of the pancreas is indicated in cases of circumscribed abscess and malignant tumors, in all cases where the pathological product can be removed completely without danger of compromising pancreatic digestion or inflicting additional injury upon important adjacent organs.

14. Ligation of the pancreas at the point or points of section should precede extirpation as a prophylactic measure against troublesome hemorrhage and extravasation of pancreatic juice into the peritoneal cavity.

15. The formation of an external pancreatic fistula by abdominal section is indicated in the treatment of cysts, abscesses, gangrene, and hemorrhage of the pancreas due to local causes.

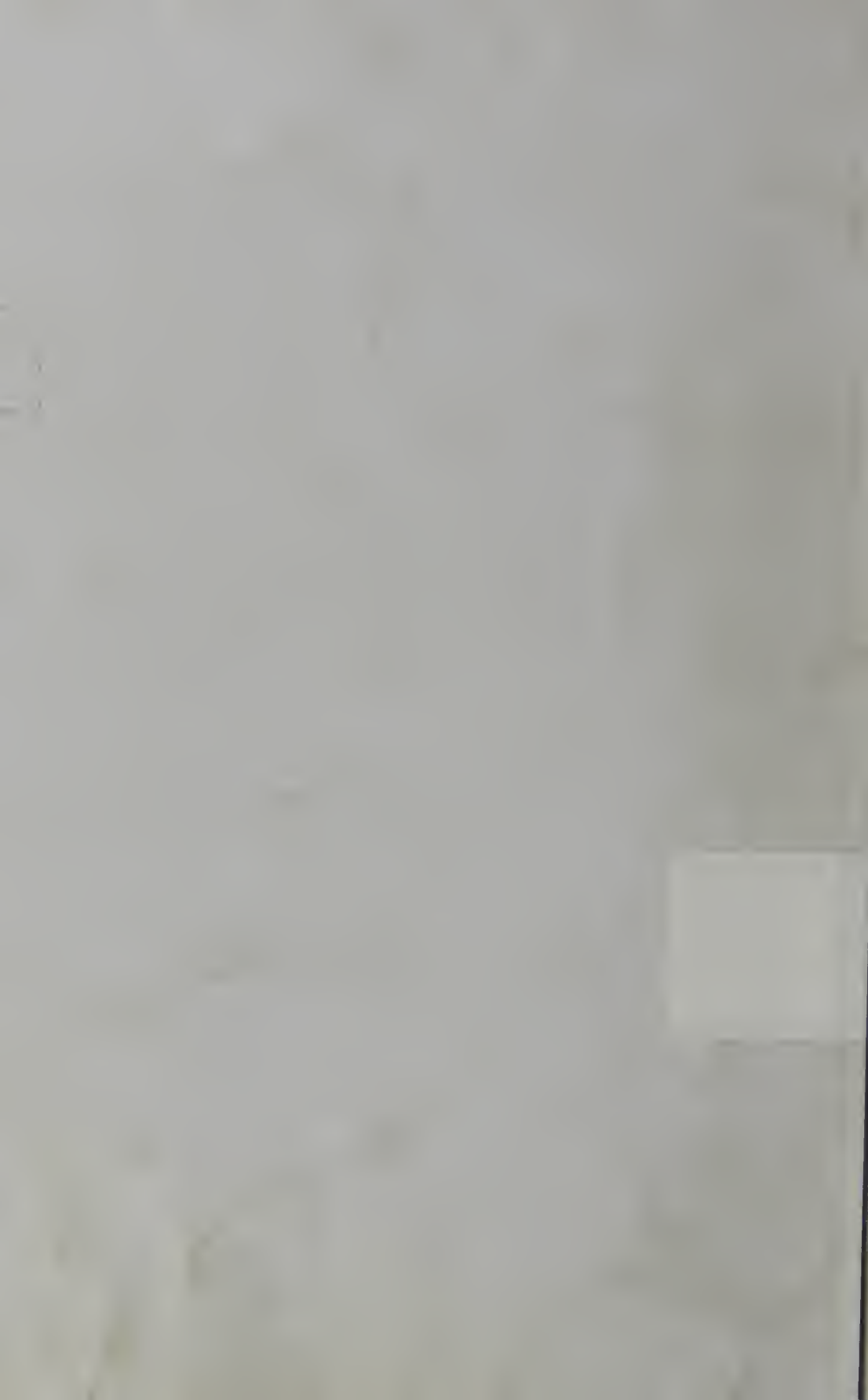
16. Abdominal section and lumbar drainage are indicated in cases of abscess or gangrene of the pancreas where it is found impossible to establish an anterior abdominal fistula.

17. Through drainage is indicated in cases of abscess and gangrene of the pancreas, with diffuse burrowing of pus in the retroperitoneal space.

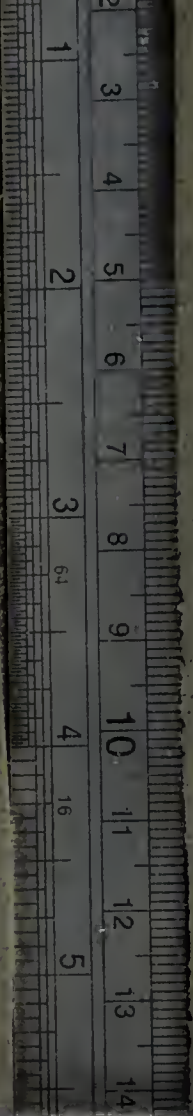
18. Removal of an impacted pancreatic calculus in the duodenal extremity of the duct of Wirsung, by taxis or incision and extraction, should be practised in all cases where the common bile-duct is compressed or obstructed by the calculus and death is threatened by cholæmia.

19. In such cases the principal source of danger, extravasation of bile into the peritoneal cavity, should be avoided by preliminary aspiration of the dilated bile-ducts, accurate closure of the visceral wound with fine silk sutures, and absolute physiological rest of the organs of digestion during the time required in the healing of the visceral wound.

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